MECHANICK
EXERCISES:
OR, THE
DOCTRINE
OF
Handy-Works.

Applied to the ART of *Smithing*, *Joinery*, *Carpentry*, and *Turning*.

By *JOSEPH MOXON*, late Member of the *Royal Society*, and HYDOGRAPHER to King *Charles* II.

The **Third Edition**, with an Addition of the **Bricklayer's Trade.**

LONDON,

Printed for, and Sold by *J. Moxon*, at the *Atlas* in *Warwick-Lane*, and at his Shop, at the Entrance of the West End of *Cornhill*, 1700.

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PREFACE.

I *See no more Reaſon, why the Sordidneſs of ſome Work-Men, ſhould be the Cauſe of Contempt upon* Manual Operations, *than that the excellent Invention of a* Mill *ſhould be Deſpis'd, becauſe a blind Horſe draws in it. And tho' the* Mechanicks *be, by ſome, accounted Ignoble and Scandalous; yet it is very well known, that many Gentlemen in this Nation, of good Rank and high Quality, are converſant in* Handy-Works: *And other Nations exceed us in numbers of ſuch. How pleaſant and healthy this their Divertion is, their Minds and Bodies find; and how Harmleſs and Honeſt, all ſober Men may judge?*

That Geometry, Aſtronomy, Perſpective, Muſick, Navigation, Architecture, &c. *are excellent Sciences, all that know but their very Names will confeſs: Yet to what purpoſe would* Geometry *ſerve, were it not to contrive Rules for* Handy-Works? *Or how could* Aſtronomy *be known to any perfection, but by Inſtruments made by Hand? What* Perſpective *ſhould we have to delight our Sight? What* Muſick *to raviſh our Ears? What* Navigation *to Guard and Enrich our Country? Or what* Architecture *to defend us from the Inconveniences of different Weather, without* Manual Operations? *Or how waſte and uſeleſs would many of the Productions of this, and other Countries be, were it not for* Manufactures.

To dive into the Original of the Mechanicks *is impoſſible, therefore I ſhall not offer at it; only I ſhall ſay, it is Rational to think, that the* Mechanicks *began with* Man, *he being the only Creature that Nature has impoſed moſt Neceſſity upon to uſe it, endow'd with greateſt Reaſon to contrive*

contrive it, and adapted with propereſt Members (as Inſtruments) to perform it.

Nor is it eaſie to find by any Authority, what part of the Mechanicks *was firſt Practiſed by* Man; *therefore I ſhall wave that too, and only conſider, that if we our ſelves were the firſt Men, what Branch of the* Mechanicks *we ſhould firſt* NEED, *and conſequently have recourſe to.*

I have conſidered, and Anſwer, That without the Invention of Smithing *primarily, moſt other* Mechanick *Invenons would be at a ſtand: The Inſtruments, or Tools, that are uſed in them, being either made of Iron, or ſome other matter, form'd by the help of Iron. But pray take Notice, that by Iron, I alſo mean Steel, it being originally Iron.*

Nor would I have you underſtand, that when I name the Mechanicks, *I mean that Rough and Barbarous ſort of working which is uſed by the Natives of* America, *and ſome other ſuch Places; for, though they did indeed make Houſes, Canoes, Earthen Pots, Bows, Arrows, &c. without the help of Iron, becauſe they had then none amongſt them; Yet ſince Iron is now known to them, they leave off their old way of working without it, and betake themſelves to the uſe of it. Nor are, at this day, (though now they have in part the uſe of Iron) their* Machines *made by good and ready Rules of* Art; *for they know neither of* Rule, Square, *or* Compaſs; *and what they do, is done by Tedious Working, and he that has the beſt Eye at Gueſſing, works beſt upon the* Straight, Square, *or* Circle, *&c.*

The Lord Bacon, *in his* Natural Hiſtory, *reckons that* Philoſophy *would be improv'd, by having the Secrets of all Trades lye open; not only becauſe much* Experimental Philoſophy, *is Coutcht amongſt them; but alſo that the* Trades *themſelves might, by a* Philoſopher, *be improv'd. Beſides, I find, that one* Trade *may borrow many Eminent Helps in* Work *of another* Trade.

Hitherto I cannot learn that any hath undertaken this Task, though I could have wiſht it had been performed by an abler hand

hand than mine; yet, ſince it is not, I have ventured upon it: For having, for many Years, been converſant in Handy-Works, *and eſpecially in thoſe* Trades *wherein the chief knowledge of all* Handy-Works *lie,* viz. Smithing, Founding, Drawing, Joynery, Turning, Engraving, Printing Books *and* Pictures, Globe *and* Map-making, Mathematical Inſtruments, &c. *I am willing to communicate to the Publick, the Knowledge I have attained to. But becauſe the* Whole *will be both a Work of Time, and great Charge, I mean to try, by the Sale of ſome few* Monthly Exerciſes, *what Encouragement I may have to run through All, if I live ſo long, and accordingly to Continue, or Deſiſt.*

I thought to have given theſe Exerciſes, *the Title of* The Doctrine of Handy-Crafts; *but when I better conſidered the true meaning of the Word* Handy-Crafts, *I found the* Doctrine *would not bear it; becauſe* Hand-Craft *ſignifies* Cunning, *or* Sleight, *or* Craft *of the Hand, which cannot be taught by Words, but is only gained by* Practice *and* Exerciſe; *therefore I ſhall not undertake, that with the bare reading of theſe* Exerciſes, *any ſhall be able to perform theſe* Handy-Works; *but I may ſafely tell you, that theſe are the* Rules *that every one that will endeavour to perform them muſt follow; and that by the true obſerving them, he may, according to his ſtock of Ingenuity and Zeal in diligence, ſooner or later, inure his hand to the* Cunning, *or* Craft *of working like a* Handy-Craft, *and conſequently be able to perform them in time.*

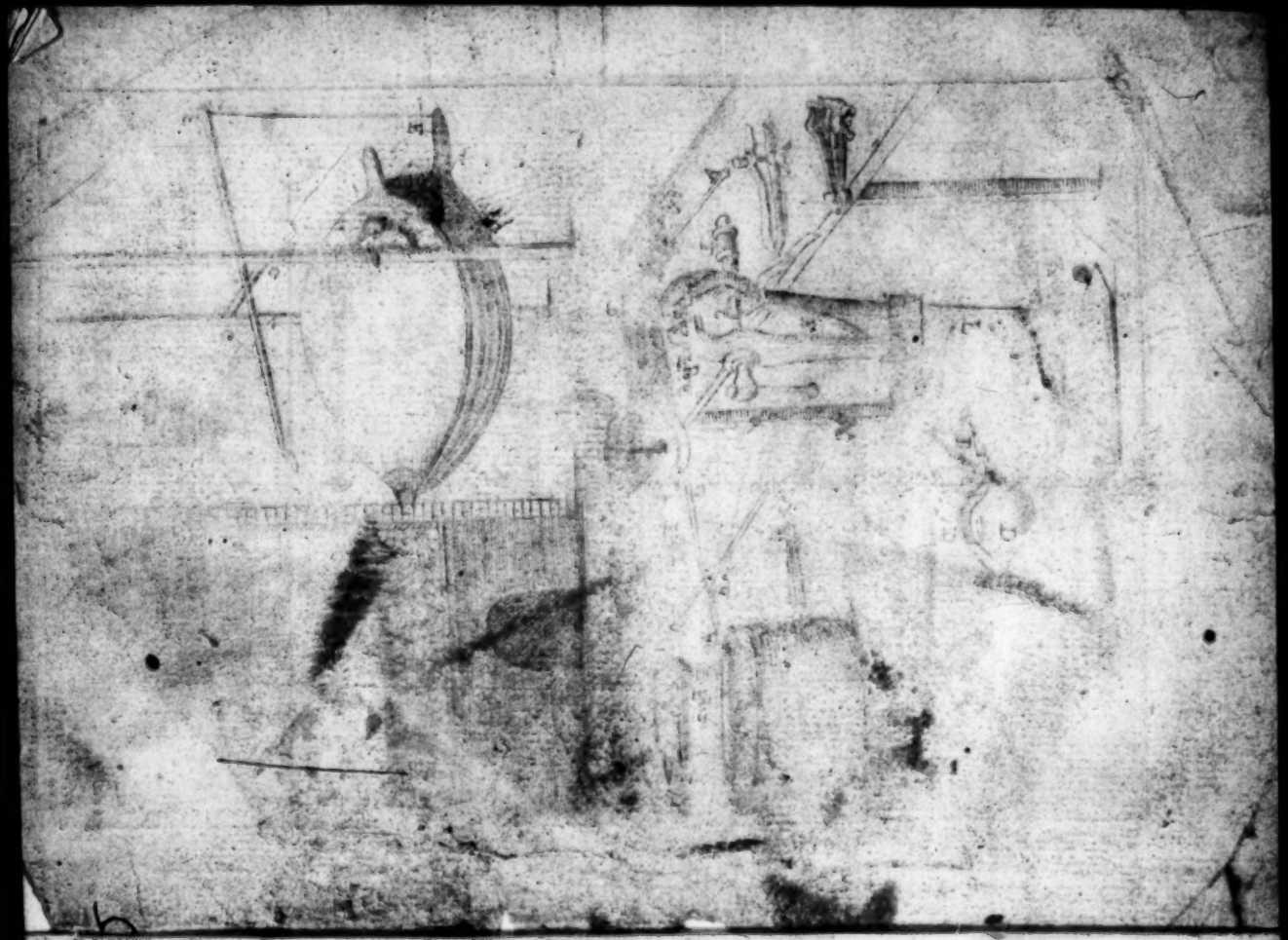
For the Reaſon aforeſaid I intend to begin with Smithing, *which comprehends not only the* Black-Smith's Trade, *but takes in all* Trades *which uſe either* Forge *or* File, *from the* Anchor-Smith, *to the* Watch-maker; *they all working by the ſame* Rules, *though not with equal exactneſs, and all uſing the ſame* Tools, *though of ſeveral Sizes from thoſe the common* Black-Smith *uſes, and that according to the various purpoſes they are applied to: And in order to it, I ſhall firſt ſhew you how to ſet up a* Forge, *and what* Tools *you muſt uſe*

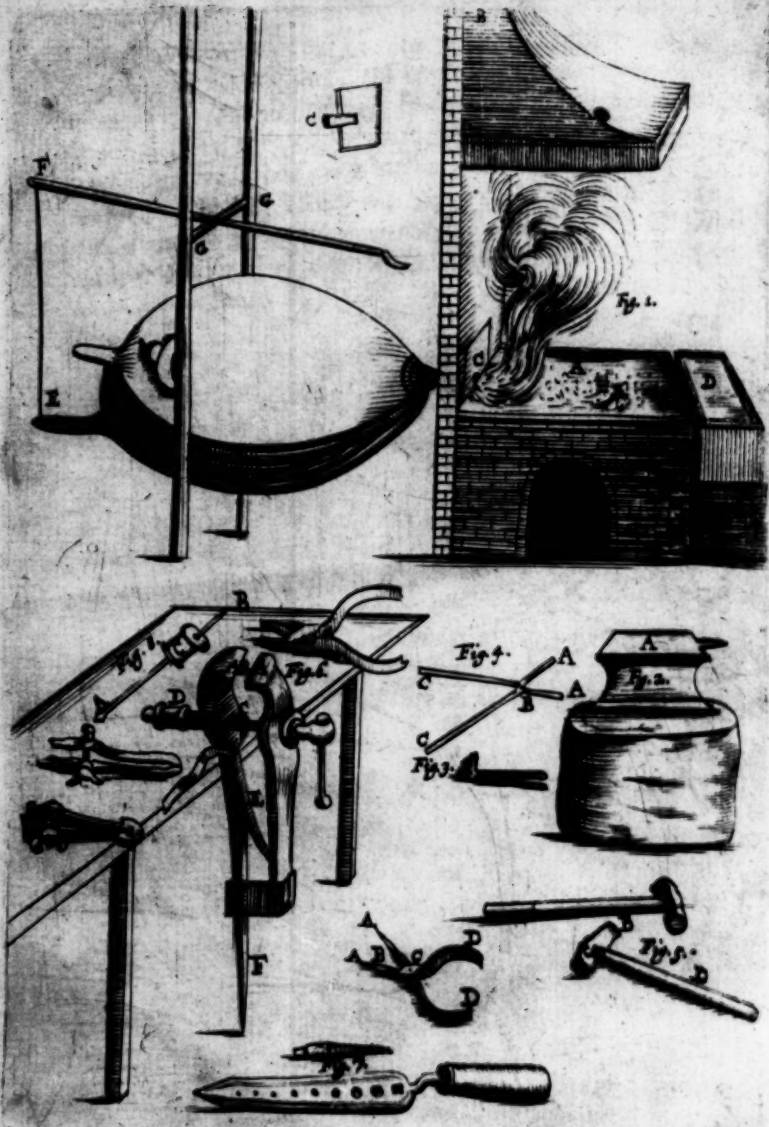
in

in the Black-Smith's *work*; *then the* Rules, *and ſeveral* Circumſtances *of* Forging, *till your Work come to the* File: *Then of the ſeveral Sorts of Iron that are commonly uſed*; *and what Sort is fitteſt for each Purpoſe. Afterwards of* Filing *in general, and the* Rules *to be obſerved in it, in the making of* Jacks, Hindges, Screws, Clocks, Watches, &c. *In which Examples, you will find all other Sorts of* Forging *or* Filing *work whatſoever comprehended. And laſtly, as a Cloſe to* Smithing, *I ſhall Exerciſe upon* Steel, *and its ſeveral Sorts, and how to Order and Temper it for its ſeveral Uſes*; *and what Sort is fitteſt for each particular purpoſe*; *as which is fitteſt for* Edge-Tools, *which for* Springs, *which for* Punches, &c.

Some perhaps would have thought it more Proper, to have introduced thoſe Exerciſes *with a more Curious, and leſs Vulgar Art, than that of* Smithing; *but I am not of their Opinion*; *for* Smithing *is, in all its parts, as curious a* Handy-Craft, *as any is: Beſides, it is a great Introduction to moſt other* Handy-Works, *as* Joynery, Turning, Founding, Printing, &c. *they* (*all with the* Smith) *working upon the* Straight, Square, *or* Circle, *though with different* Tools, *upon different* Matter; *and they all having dependance upon the* Smith's Trade, *and not the* Smith *upon them. But having done with* Smithing, *I ſhall, God willing, proceed to thoſe, and all other* Handy-Works *whatſoever, that work by* Geometrical *Principles.*

J. MOXON.




F
C
G
I
B
Fig. 1.
D
Fig. 2.
Fig. 3.
Fig. 4.
A
Fig. 5.

MECHANICK EXERCISES:

OR,

The Doctrine of *Handy-Works.*

Of SMITHING *in General.*

Definition.

SMITHING is an Art-Manual, by which an irregular Lump (or ſeveral Lumps) of Iron, is wrought into an intended Shape.

This Definition, needs no Explanation; therefore I ſhall proceed to give you an Account of the Tools a Smith uſes; not but that (they being ſo common) I ſuppoſe you do already know them; but partly becauſe they may require ſome pre-caution in ſetting them up fitteſt to your uſe, and partly becauſe it behoves you to know the Names, Smiths call the ſeveral parts of them by, that when I name them in Smith's Language (as I ſhall oft have occaſion to do in theſe *Exerciſes*) you may the eaſier underſtand them, as you read them.

Of ſetting up a Smith's Forge.

THE *Hearth*, or Fire-place of the *Forge* marked A (in Plate 1.) is to be built up from your floor with Brick about two foot and an half, or ſometimes two foot nine Inches high, according to the purpoſe you deſign your *Forge* for; for if your *Forge* be intended for heavy work, your *Hearth* muſt lie lower than it need be for light work, for eaſineſs of management, and ſo broad as you think convenient: It may be built with hollow Arches underneath, to ſet ſeveral things out of the way. The

Back of the *Forge* is built upright to the top of the Ceiling, and incloſed over the Fire-place with a *Hovel*, which ends in a *Chimney* to carry away the Smoak, as B. In the back of the *Forge* againſt the Fire-place, is fixed a thick Iron Plate, and a taper Pipe in it about five Inches long, called a *Tewel*, or (as ſome call it) a *Tewel-Iron* marked *, which Pipe comes through the Back of the *Forge*, as at C. Into this taper Pipe or *Tewel* is placed the Noſe, or Pipe of the *Bellows*. The Office of this *Tewel*, is only to preſerve the Pipe of the Bellows, and the back of the *Forge* about the Fire-place from burning. Right againſt the Back is placed at about twenty Inches, or two foot diſtance the *Trough*, and reaches commonly through the whole breadth of the *Forge*, and is as broad and deep as you think good, as at D. The *Bellows* is placed behind the Back of the *Forge*, and hath, as aforeſaid, its Pipe fitted into the Pipe of the *Tewel*, and hath one of its Boards fixed ſo that it move not upwards or downwards. At the Ear of the upper Bellows Board is faſtened a *Rope*, or ſometimes a *Thong* of Leather, or an Iron *Chain* or *Rod*, as E; which reaches up to the *Rocker*, and is faſtened there to the farther end of the Handle, as at F. This *Handle* is faſtened a-croſs a *Rock-ſtaff*, which moves between two Cheeks upon the *Center-pins* in two Sockets, as at G. So that by drawing down this Handle, the moving Board of the *Bellows* riſes, and by a conſiderable weight ſet on the top of its upper Board ſinks down again, and by this Agitation performs the Office of a pair of *Bellows*.

Of the Anvil.

THE ſhape of a Black Smith's *Anvil* I have inſerted in this Figure, though it is ſometimes made with a *Pike*, or *Bickern*, or *Beak-iron*, at one end of it, whoſe uſe I ſhall ſhew you when I come to round hollow work. Its *Face* muſt be very flat and ſmooth, without Flaws, and

and ſo hard, that *a File will not touch it* (as Smiths ſay, when a File will not cut, or race it.) The upper Plain A. is called the *Face*; it is commonly ſet upon a wooden *Block*, that it may ſtand very ſteady and ſolid, and about two foot high from the floor, or ſometimes higher, according to the ſtature of the Perſon that is to work at it.

Of the Tongs.

THere are two ſorts of *Tongs* uſed by Smiths; the one the *Straight noſed Tongs*, uſed when the work is ſhort, and ſomewhat flat, and generally for all Plate Iron. The other *Crooked nos'd Tongs*, to be uſed for the forging ſmall Bars, or ſuch thicker work, as will be held within the Returns of their *Chaps*. The *Chaps* are placed near the Joint, becauſe, that conſidering the length of the *Handles*, they hold the Iron faſter than they would do, were they placed farther from the Joint, as in the Fig. 3, 4. A the *Chaps*, B the *Joint*, CC the *Handles*.

Of the Hammer, *and the* Sledge.

THere are ſeveral ſorts of *Hammers* uſed by Black-Smiths; as firſt the *Hand-hammer*, which is ſometimes bigger, or leſs, according to the Strength of the Work-man; but it is a *Hammer* of ſuch weight, that it may be weilded, or governed, with one hand at the *Anvil*. Secondly, the *Up-hand Sledge*, uſed by under-Workmen, when the Work is not of the largeſt, yet requires help to batter, or *draw it out*; they uſe it with both their Hands before them, and ſeldom lift their *Hammer* higher than their head. Thirdly, the *About Sledge* is the biggeſt *Hammer* of all, and is alſo uſed by under-Workmen, for the battering, or *drawing out* of the largeſt Work; and then they hold the farther end of the *Handle* in both their Hands, and ſwinging the *Sledge* above their Heads, they at Arms end let fall as heavy a Blow as they can upon the Work. There is

alſo another *Hammer* uſed by them, which they call a *Rivetting-hammer*. This is the ſmalleſt *Hammer* of all, and very rarely uſed at the *Forge*, unleſs your Work prove very ſmall; but upon cold Iron it is uſed for riveting, or ſetting ſtraight, or crooking ſmall work. In Fig. 5. A the *Face*, B the *Pen*, C the *Eye*, D the *Handle*.

Of the Vice.

THE *Vice* muſt be ſet up very firmly that it ſhake not, and ſtand upright with its *Chaps*, parallel or range with your *Work-bench*; becauſe ſquare filing, is a great piece of good Workmanſhip in a Smith; and ſhould the Vice not ſtand upright, and range with the Work-bench, the *Chaps* pinching upon two ſquare ſides, would make the top ſide of your work either lean towards you, or from you; and conſequently you filing (as a good Workman ought to do) upon the flat, or Horizontal Plain of your work, would take off more of that Angle, or Edge, which riſes higher than the Plain, and leſs off that Edge that lies lower than the Plain; ſo that one Angle being higher, or lower, than the other, your work inſtead of being filed *Square*, would be filed *Square-wiſe*, when you ſhall have filed all its flat ſides, and that more or leſs, according to the leaning of the *Chaps* of your *Vice*. AA the *Face*, hath its two ends lie in a ſtraight Line with the middle of its *Face*, or *Plain*. B the *Chaps* muſt be cut with a Baſtard Cut, and very well tempered, C the *Screw Pin*, cut with a ſquare ſtrong Worm. D the *Nut*, or *Screw Box*, hath alſo a ſquare *Worm*, and is brazed into the round *Box*. E the *Spring* muſt be made of good Steel, and very well temper'd: Where note, that the wider the two ends of the *Spring* ſtand aſunder, the wider it throws the *Chaps* of the *Vice* open. F the *Foot* muſt be ſtraight, and therefore will be the ſtronger to bear good heavy Blows upon the work ſcrewed in the *Chaps* of the *Vice*, that it neither bow, or tremble.

Of

Of the Hand-Vice.

OF the *Hand-Vice* are two Sorts, one is called the *Broad Chapt Hand-Vice*, the other the *Squar Nos'd Hand-Vice*. The Office of the *Hand-Vice*, is to hold ſmall work in, that may require often turning about; it is held in the left hand, and each part of your work turned upwards ſucceſſively, that you have occaſion to file with your right. The *Square-nos'd Hand-Vice* is ſeldom uſed, but for filing ſmall Globulous Work, as the Heads of Pins that round off towards the Edges, &c. And that becauſe the *Chaps* do not ſtand ſhouldering in the way, but that the flat of the *File* may the better come at the Edges. Their *Chaps* muſt be cut as the *Vice* aforeſaid, and well tempered.

Of the Plyers.

PLyers are of two Sorts, *Flat Nos'd*, and *Round Nos'd*. Their Office is to hold, and faſten upon all ſmall work, and to fit it in its place. The *Round Nos'd Plyers* are uſed for turning, or bowing Wyer, or ſmall Plate, into a circular Form. The *Chaps* of the *Flat Nos'd Plyers*, muſt alſo be cut and temper'd, as the *Chaps* of the *Vice*. A the *Noſe*, B the *Chaps*, C the *Joint*, D D the *Handles*.

Of the Drill, *and* Drill-Bow.

Drills are uſed for the making ſuch Holes, as *Punches* will not conveniently ſerve for, as a piece of work that hath already its Shape, and muſt have an hole, or more, made in it. Here the force of a *Punch*, will ſet your work out of order and ſhape, becauſe it will both batter the Surface of the Iron, and ſtretch its Sides out: The ſhank of a Key alſo, or ſome ſuch long Hole, the *Punch* cannot ſtrike, becauſe the Shank is not forged with ſubſtance ſufficient; but the *Drill*, tho' your work be filed

and

and poliſh'd, never batters or ſtretches it, but cuts a true round Hole, juſt in the point you firſt place it. You muſt have ſeveral Sizes of *Drills*, according as your work may require. The ſhape in Fig. 8. is enough to ſhew the Faſhion of it; but it muſt be made of good Steel, and well tempered. A the *Point*, A B the *Shank*, C the *Drill-barrel*: Where note, that the bigger the *Drill-barrel* is, the eaſier it runs about, but leſs ſwift.

And as you muſt be provided with ſeveral *Drills*, ſo you may ſometimes require more than one *Drill-bow*, or at leaſt, ſeveral *Drill-ſtrings*; the ſtrongeſt Strings for the largeſt *Drills*, and the ſmalleſt *Strings* for the ſmalleſt *Drills*: But you muſt remember, that whether you uſe a ſmall or ſtrong *String*, you keep your *Drill-bow* ſtraining your String pretty ſtiff, or elſe your String will not carry your Barrel briskly about. But your String and Bow, muſt both be accommodated to the Size of your *Drill*; and if both, or either, be too ſtrong, they will break, or bend your *Drill*; or if too weak, they will not carry about the Barrel, as aforeſaid.

The *Drill-Plate*, or *Breaſt-plate*, is only a piece of flat Iron, fixt upon a flat Board, which Iron hath an hole punched a little way into it, to ſet the blunt end of the Shank of the *Drill* in, when you drill a hole: Workmen inſtead of it, many times uſe the *Hammer*, into which they prick a hole a little way on the ſide of it, and ſo ſet the *Hammer* againſt their Breaſt.

Of the Screw-Plate, *and its* Taps.

THE *Screw-Plate* is a Plate of Steel well temper'd, with ſeveral holes in it, each leſs than other, and in thoſe *Holes* are *Threds* groved inwards; into which *Groves*, fit the reſpective *Taps* that belong to them. The *Taps* that belong to them, are commonly made tapering towards the Point, as Fig. 7. ſhews. But theſe tapering *Taps*, will not ſerve for ſome ſorts of works, as I ſhall ſhew in its proper place. Theſe

Theſe are the moſt Eſſential Tools uſed in the Black-Smith's Trade; but ſome accidental work, may require ſome accidental Tools, which, as they may fall in, I ſhall give you an account of in convenient place.

Of Forging *in general.*

I Think it needleſs to tell you how to make your Fire, or blow it, becauſe they are both but Labourer's work; nor how little, or big, it need to be, for your own Reaſon will, by the Size of your work, teach you that; only let me tell you the Phraſe Smith's uſe for [Make the Fire] is, *Blow up the Fire*, or ſometimes, *Blow up the Coals.*

When it is burning with the Iron in it, you muſt, with the *Slice*, clap the Coals upon the out-ſide cloſe together, to keep the heat in the body of the Fire; and as oft as you find the Fire begin to break out, clap them cloſe again, and with the *Waſher* dipt in Water, wet the out-ſide of the Fire to damp the out-ſide, as well to ſave Coals, as to ſtrike the force of the Fire into the in-ſide, that your work may heat the ſooner. But you ought oft to draw your work a little way out of the Fire, to ſee how it *takes its Heat*, and quickly thruſt it in again, if it be not hot enough: For each purpoſe your work is deſigned to, ought to have a proper *Heat* ſuitable to that purpoſe, as I ſhall ſhew you in the ſeveral *Heats* of Iron: For if it be too cold, it will not *feel the weight of the Hammer* (as Smiths ſay, when it will not batter under the *Hammer*) and if it be too hot, it will *Red-ſear*, that is, break, or crack under the *Hammer*, while it is working between hot and cold.

Of the ſeveral Heats *Smiths take of their Iron.*

THere are ſeveral degrees of *Heats* Smiths take of their Iron, each according to the purpoſe of their work. As firſt, a *Blood-red Heat.* Secondly, a *White Flame*

Flame Heat. Thirdly, a *Sparkling*, or *Welding Heat.*

The *Blood-red Heat* is uſed when Iron hath already its form and ſize, as ſometimes ſquare Bars, and Iron Plates, &c. have, but may want a little Hammering to ſmooth it. Uſe then the Face of your *Hand-hammer*, and with light flat Blows, hammer down the irregular Riſings into the Body of your Iron, till it be ſmooth enough for the File. And note, that it behoves a good Workman, to Hammer his Work as true as he can; for one quarter of an hour ſpent at the *Forge*, may ſave him an hours work at the *Vice*,

The *Flame*, or *White Heat*, is uſed when your Iron hath not its Form or Size, but muſt be forged into both; and then you muſt take a piece of Iron thick enough, and with the *Pen* of your *Hammer*, (or ſometimes, according to the ſize of your work, uſe two or three pair of hands with *Sledges* to) batter it out; or, as Workmen call it, to *draw it out*, till it comes to its breadth, and pretty near its ſhape; and ſo by ſeveral *Heats*, if your Work require them, frame it into Form and Size; then with the Face of your *Hand-hammer*, ſmooth your work from the Dents the *Pen* made, as you did with a *Blood-red Heat.*

A *Sparkling*, or *Welding Heat*, is only uſed when you *double up* your Iron (as Smiths call it) to make it thick enough for your purpoſe, and ſo *weld*, or work in the *doubling* into one another, and make it become one entire lump; or it is uſed when you join ſeveral Bars of Iron together to make them thick enough for your purpoſe, and work them into one Bar; or elſe it is uſed when you are to join, or *weld*, two pieces of Iron together end to end, to make them long enough; but, in this caſe, you muſt be very quick at the *Forge*; for when your two ends are throughout of a good *Heat*, and that the inſide of the Iron be almoſt ready to Run, as well as the outſide, you muſt very haſtily ſnatch them both out of the Fire together, and (after you have with the Edge of your

Hammer

Hammer ſcraped off ſuch Scales or Dirt as may hinder their incorporating) with your utmoſt diligence clap your left hand-piece upon your right hand-piece, and with all ſpeed (leaſt you loſe ſome part of your good Heat) fall to Hammering them together, and work them ſoundly into one another ; and this, if your Bars be large, will require another, or ſometimes two or three pair of Hands beſides your own to do ; but if it be not throughly *welded* at the firſt *Heat*, you muſt reiterate your *Heats* ſo oft, till they be throughly *welded*; then with a *Flame Heat* (as before) ſhape it, and afterwards ſmooth it with a *Blood-red Heat*. To make your Iron come the ſooner to a *Welding-heat*, you muſt now and then with your *Hearth-ſtaff* ſtir up the Fire, and throw up thoſe Cinders the Iron may have run upon; for they will never burn well, but ſpoil the reſt of the Coals, and take a little white Sand between your Finger and your Thumb, and throw upon the heating Iron, then with your Slice, quickly clap the outſide of your Fire down again ; and with your *Waſher* dipt in Water, damp the outſide of the Fire to keep the Heat in.

But you muſt take ſpecial Care that your Iron *burn* not in the Fire, that is, that it do not *run* or melt ; for then your Iron will be ſo brittle, that it will not endure Forging without breaking, and ſo hard, that a *File* will not touch it.

Some Smiths uſe to ſtrew a little white Sand upon the *Face* of the *Anvil* alſo, when they are to hammer upon a *Welding-heat*; for they ſay it makes the Iron *weld*, or incorporate the better.

If through Miſtake, or ill management, your Iron be too thin, or too narrow towards one of the ends ; then if you have ſubſtance enough (and yet not too long) you may *up-ſet* it, that is, take a *Flame Heat*, and ſet the heated end upright upon the *Anvil*, and hammer upon the

cold end, till the heated end be beat, or *up-ſet*, into the Body of your Work. But if it be a long piece of work, and you fear its length may wrong the middle, you muſt hold it in your left hand, and lay it flat on the *Anvil*; but ſo as the heated end intended to be *up-ſet*, may lie a little over the further ſide of the *Anvil*, and then with your *Hand-hammer* in your right hand, beat upon the heated end of your work, minding that every ſtroak you take, you hold your work ſtiff againſt the *Face* of the *Hammer*. Afterwards ſmooth it again with a *Blood-red Heat*.

If you are to Forge a *Sholder* on one, or each ſide of your work, lay the Shank of your Iron at the place where your *Sholder* muſt be on the edge of your *Anvil* (that edge which is moſt convenient to your hand) that if more *Sholders* be to be made, turn them all ſucceſſively, and hammer your Iron ſo, as that the Shank of the Iron that lies on the flat of the *Anvil*, feel as well the weight of your Blows, as the *Sholder* at the edge of the *Anvil*; for ſhould you lay your blows on the edge of the *Anvil* only, it would inſtead of flatting the Shank to make the *Sholder*, cut your work through.

Your Work will ſometimes require to have holes punched in it at the Forge, you muſt then make a Steel *Punch* to the ſize and ſhape of the hole you are to ſtrike, and harden the point of it without tempering, becauſe the heat of the Iron will ſoften it faſt enough, and ſometimes too faſt; but then you muſt re-harden it; then taking a *Blood-heat* of your Iron, or if it be very large, almoſt a *Flame-heat*; lay it upon your *Anvil*, and with your left hand, place the point of the *Punch* where the hole muſt be, and with the *Hand-hammer* in your right hand punch the hole; or if your work be heavy, you may hold it in your left hand, and with your Punch fixed at the end of a *Hoop-ſtick*, or ſome ſuch Wood, hold the ſtick in your right hand, and place the point of your *Punch* on the work where the hole muſt be,

and

and let another Man ſtrike, till your Punch come pretty near the bottom of your work; which when it does, the ſides of your work round about the hole, will riſe from the Face of the *Anvil*, and your Punch will print a bunching mark upon the hole of a *Bolſter*, that is, a thick Iron with a hole in it, and placing your Punch, as before, ſtrike it through. But you muſt note, that as oft as you ſee your Punch heat, or change Colour, you take it out of the hole, and pop it into Water to re-harden it, or elſe it will batter in the hole you intend to ſtrike, and not only ſpoil it ſelf, but the Work too, by running aſide in the Work. Having punched it through on the one ſide, turn the other ſide of your work, and with your Hammer ſet it flat and ſtraight, and with a *Blood-heat* punch it through on the other ſide alſo; ſo ſhall that hole be fit for the *File*, or ſquare bore, if the curioſity of your purpoſed Work cannot allow it to paſs without filing. When your Work is Forged, do not quench it in water to cool it, but throw it down upon the *Floor*, or *Hearth*, to cool of it ſelf; for the quenching it in water will harden it; as I ſhall ſhortly ſhew you, when I come to the Tempering of Steel.

Of Brazing *and* Soldering.

YOU may have occaſion ſometimes to *Braze* or *Solder* a piece of work; but it is uſed by Smiths only, when their work is ſo thin, or ſmall, that it will not endure *Welding*. To do this, take ſmall pieces of Braſs, and lay them on the place that muſt be brazed, and ſtrew a little Glaſs beaten to powder on it to make it run the ſooner, and give it a *Heat* in the *Forge*, till (by ſometimes drawing it a little way out of the Fire) you ſee the Braſs run. But if your work be ſo ſmall, or thin, that you may fear the Iron will run as ſoon as the Braſs, and ſo you loſe your work in the Fire, then you muſt make a *Loam* of three parts Clay, and one part Horſe-dung, and after

they are wrought and mingled very well together in your hands, wrap your work with the Braſs, and a little beaten Glaſs upon the place to be brazed cloſe in the *Loam*, and laying it a while upon the Hearth of the *Forge* to dry, put the Lump into the Fire, and blow the *Bellows* to it, till you perceive it have a full *Heat*, that is, till the Lump look like a well burnt Coal of Fire; then take it out of the Fire, and let it cool: Afterwards break it up, and take out your Work.

Thus much of Forging in general. It remains now, that you know what Sorts of Iron are fitteſt for the ſeveral Uſes, you may have occaſion to apply them.

Of ſeveral Sorts of Iron, *and their proper Uſes.*

IT is not my purpoſe, in this place, to tell you how Iron is made, I ſhall deferr that till I come to treat of Mettals, and their Refinings. Let it at preſent ſatisfie thoſe that know it not, that Iron is, by a violent Fire, melted out of hard Stones, called *Iron-Stones*; of theſe *Iron-Stones*, many Countries have great plenty. But becauſe it waſts ſuch great quantities of Wood to draw the Iron from them, it will not, in many Places, quit coſt to uſe them. In moſt parts of *England*, we have abundance of theſe *Iron-ſtones*; but our *Engliſh* Iron, is generally a courſe ſort of Iron, hard and brittle, fit for Fire-bars, and other ſuch courſe Uſes; unleſs it be about the Forreſt of *Dean*, and ſome few Places more, where the Iron proves very good.

Swediſh Iron is of all Sorts, the beſt we uſe in *England*. It is a fine tough ſort of Iron, will beſt endure the Hammer, and is ſofteſt to file; and therefore moſt coveted by Workmen, to work upon.

Spaniſh Iron, would be as good *Swediſh* Iron, were it not ſubject to *Red-ſear*, (as Workmen phraſe it) that is to crack betwixt hot and cold. Therefore when it falls under your hands, you muſt tend it more earneſtly at the

Forge.

Forge. But tho' it be a good, tough, ſoft Iron, yet for many Uſes, Workmen will refuſe it, becauſe it is ſo ill, and un-evenly wrought in the Bars, that it coſts them a great deal of labour to ſmooth it; but it is good for all great works that require *welding*, as the bodies of Anvils, Sledges, large Bell-clappers, large Peſtles for Mortars, and all thick, ſtrong Bars, *&c.* But it is particularly choſen by *Anchor-Smiths*, becauſe it abides the Heat better than other Iron, and when it is well wrought, is tougheſt.

There is ſome Iron comes from *Holland* (though in no great quantity) but is made in *Germany*. This Iron is called *Dort Squares*, only becauſe it comes to us from thence, and is wrought into ſquare Bars three quarters of an Inch ſquare. It is a bad, courſe Iron, and only fit for ſleight Uſes, as Window-Bars, Brewers-Bars, Fire-Bars, *&c.*

There is another ſort of Iron uſed for making of *Wyer*, which of all Sorts is the ſoughteſt and tougheſt: But this Sort is not peculiar to any Country, but is indifferently made where any Iron is made, though of the worſt ſort; for it is the firſt Iron that runs from the *Stone* when it is melting, and is only preſerved from the making of *Wyer*.

By what hath been ſaid, you may ſee that the ſofteſt and tougheſt Iron is the beſt: Therefore when you chuſe Iron, chuſe ſuch as bows ofteneſt before it break, which is an Argument of Toughneſs; and ſee it break ſound within, be gray of Colour like broked Lead, and free from ſuch gliſtering Specks you ſee in broken *Antimony*, no flaws or diviſions in it; for theſe are Arguments that it is ſound, and well wrought at the Mill.

Of Filing *in general.*

THE ſeveral ſorts of Files that are in common uſe are the *Square*, the *Flat*, the *three Square*, the *half Round*, the *Round*, the *Thin File*, *&c.* All theſe ſhapes you muſt have

have of ſeveral *Sizes*, and of ſeveral *Cuts*. You muſt have them of ſeveral ſizes, as well becauſe you may have ſeveral ſizes of work, as for that it ſometimes falls out that one piece of work may have many parts in it joined and fitted to one another, ſome of them great, and others ſmall: And you muſt have them of ſeveral *Cuts*, becauſe the *Rough-tooth'd File* cuts faſter than the *Baſtard-tooth'd File*, the *Fine-tooth'd File* faſter than the *Smooth-tooth'd File*.

The *Rough* or *Courſe-tooth'd File* (which if it be large, is called a *Rubber*) is to take off the unevenneſs of your work which the *Hammer* made in the Forging; the *Baſtard-tooth'd File* is to take out of your work, the deep Cuts or file-ſtroaks the *Rough-file* made; the *Fine-tooth'd file* is to take out the cuts, or file-ſtroaks, the *Baſtard-file* made; and the *Smooth-file* is to take out thoſe cuts, or file-ſtroaks, that the *fine File* made.

Thus you ſee how the *Files* of ſeveral *Cuts* ſucceed one another, till your Work is ſo ſmooth as it can be filed. You may make it yet ſmoother with *Emerick*, *Tripoli*, &c. But of that in its proper place, becauſe it ſuits not with this Section of *Filing*.

You muſt take care when you uſe the *Rough File*, that you go very lightly over thoſe dents the *Hammer* made in your work, unleſs your work be forged ſomewhat of the ſtrongeſt, for the dents being irregularities in your work, if you ſhould file away as much in them, as you do off the Eminencies or Riſings, your work (whether it be ſtraight or circular) would be as irregular, as it was before you filed it: And when you file upon the Prominent, or riſing Parts of you Work, with your *courſe cut File*, you muſt alſo take care that you file them not more away than you need, for you may eaſily be deceived; becauſe the *courſe File* cuts deep, and makes deep ſcratches in the Work; and before you can take out thoſe deep ſcratches with your finer cut Files, thoſe places where

where the Risings were when your work was forged, may become dents to your Hammer dents; therefore file not those Risings quite so low, as the dents the Hammer made, but only so low, as that the scratches the *Rough-file* makes may lie as low, or deep in your work, as your Hammer dents do; for then, when you come with your smoother Cut Files, after your *rough File*, the scratches of your *rough File*, and your Hammer stroaks, or dents, may both come out together. But to do this with greater certainty, hold your File so, that you may keep so much of the length of your File as you can to rub, range, (or, as near range as you can) upon the length of your work; for so shall the File enter upon the second Rising on your work, before it goes off the first, and will slip over, and not touch the dent or hollow between the two Risings, till your Risings are brought into a straight line with your hollow dent. But of this more shall be said when I come to the Practice of Filing, upon several particular sorts of work.

If it be a Square Bar, (or such like) you are to file upon, all its Angles, or Edges, must be left very sharp and straight. Therefore your *Vice* being well set up, according to fore-going Directions, you must in your filing athwart over the *Chaps* of the *Vice*, be sure to carry both your hands you hold the *file* in, truly Horizontal, or flat over the Work; for should you let either of your hands mount, the other would dip, and the edge of that Square it dips upon would be taken off; and should you let your hand move never so little circularly, both the Edges you file upon would be taken off, and the Middle of your intended Flat, would be left with a Rising on it. But this Hand-craft, you must attain to by Practice; for it is the great Curiosity in Filing.

If

If it be a round Piece, or Rod of Iron, you are to file upon, what you were forbid upon Square Work, you muſt perform on the Round; for you muſt dip your Handle-hand, and mount your end-hand a little, and laying pritting near the end of your File to the Work, file circularly upon the Work, by mounting your Handle-hand by degrees, and dipping your End-hand, in ſuch manner, as when the Middle of your File comes about the top of your Work, your File may be flat upon it, and as you continue your ſtroaks forwards, ſtill keep your hands moving circularly till you have finiſhed your full Stroak, that is, a Stroak the whole length of the File. By this manner of Circular filing, you keep your Piece, or Rod round; but ſhould you file flat upon the top of your work, ſo many times as you ſhall remove, or turn your work in the *Vice*, ſo many Flats, or Squares, you would have in your work; which is contrary to your purpoſe.

When you thruſt your *File* forwards lean heavy upon on it, becauſe the *Teeth* of the *File* are made to cut forwards; but when you draw your *File* back, to recover an other thruſt, lift, or bear the File lightly juſt above the work; for it cuts not coming back.

Thus much of FILING in General.

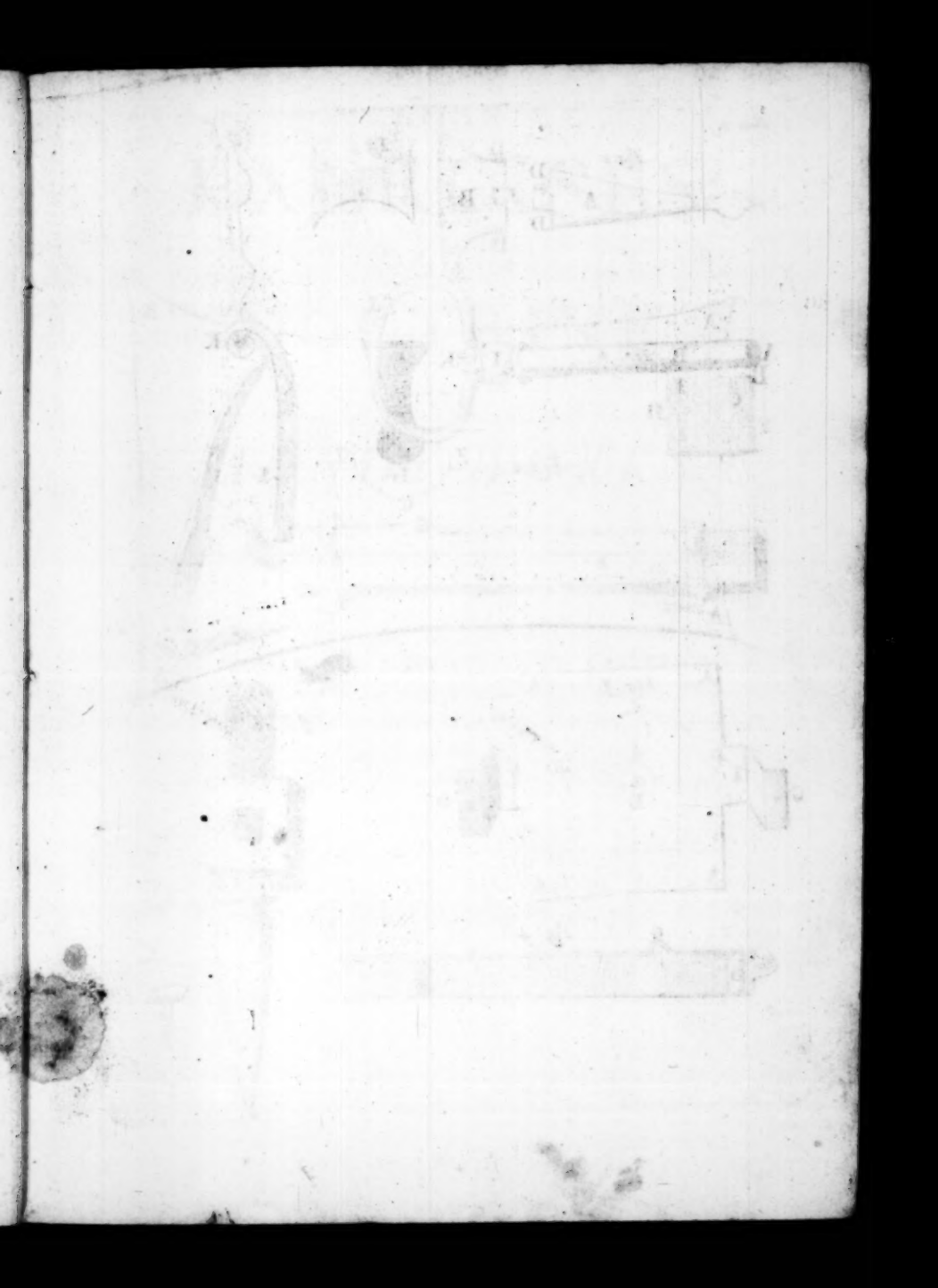
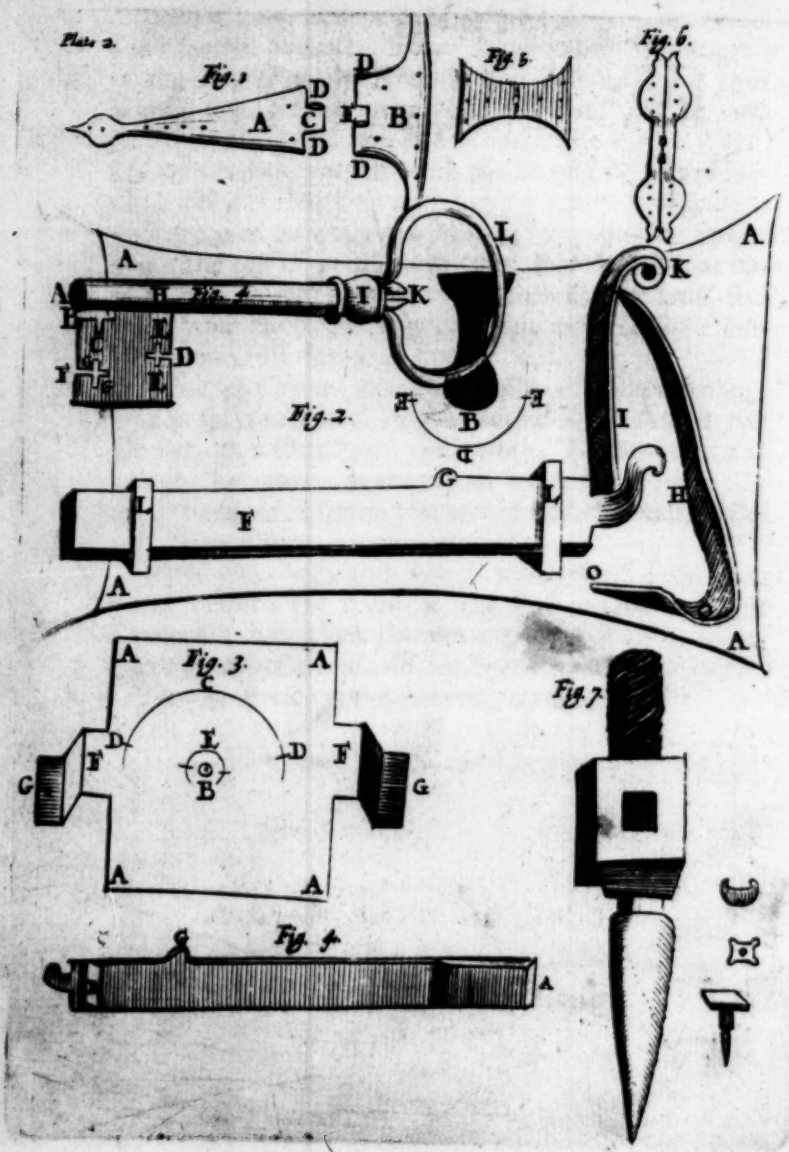
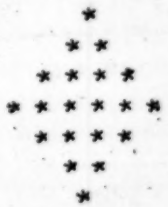


Plate 2.



MECHANICK EXERCISES: OR, THE DOCTRINE OF *HANDY-WORKS.*



By *Joseph Moxon*, late Member of the *Royal Society*, and *Hydographer* to King *Charles* II.

LONDON,

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MECHANICK EXERCISES:

OR,

The Doctrine of *Handy-Works.*

Applied to the making of Hinges, Locks, Keys, Screws and Nuts Small and Great.

Of Hinges.

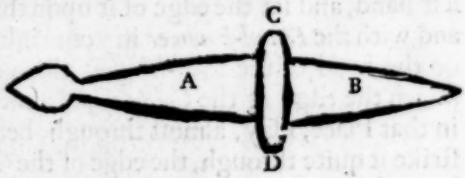
IN *Fig.* 1. A the *Tail*, B the *Croſs*, C D D D D E the *Joint*, D D D D the *Pin-hole*. When the *Joint* at C on the *Tail*, is pin'd in the *Joint* at E in the *Croſs*, the whole *Hinge* is called a *Croſs-Garnet*.

Hinges, if they be ſmall (as for Cup-board doors; *Boxes*, &c.) are cut out of cold Plate Iron with the *a Cold-Chiſſel*, but you muſt mark the out-lines of your intended *Hinge*, as *Fig.* 1. the *Croſs-Garnet*, either with Chalk, or elſe raſe upon the Plate with the corner of the *Cold-Chiſſel*, or any other hardned Steel that will ſcratch a bright ſtroke upon the Plate; and then laying the Plate flat upon the *Anvil*, if the Plate be large, or upon the *b Stake*, if the Plate be ſmall, take the *Cold-Chiſſel* in your left hand, and ſet the edge of it upon that Mark, or Raſe, and with the *Hand-hammer* in your right hand, ſtrike upon the head of the *Cold-Chiſſel*, till you cut, or rather punch the edge of the *Cold-Chiſſel* almoſt thro' the Plate in that Place, I ſay, almoſt through, becauſe, ſhould you ſtrike it quite through, the edge of the *Cold-Chiſſel* would be in danger of battering, or elſe breaking; for the *Face* of the *Anvil* is hardned Steel, and a light blow upon its *Face* would wrong the edge of the *Cold-Chiſſel*; be-

ſides, it ſometimes happens, that the *Anvil*, or *Stake*, is not all over ſo hard as it ſhould be, and then the *Cold-Chiſſel* would cut the *Face* of the *Anvil*, or *Stake*, and conſequently ſpoil it: Therefore when the edge of the *Cold-Chiſſel* comes pretty near the bottom of the Plate, you muſt lay but light blows upon the *cold Chiſſel*; and yet you muſt ſtrike the edge of the *Cold-Chiſſel* ſo near through the bottom of the Plate, that you may break the remaining ſubſtance aſunder with your Fingers, or with a pair of *Plyers*, or ſometimes by pinching the Plate in the *Vice*, with the Cut-place cloſe to the Superficies of the *Chaps* of the *Vice*; and then with your Fingers and Thumb, or your whole hand, wriggle it quite aſunder, But having cut one breadth of the *Cold-Chiſſel*, remove the edge of it forward in the Raſe, and cut another breadth, and ſo move it ſucceſſively, till your whole intended ſhape be cut out of the Plate.

When you cut out an *Hinge*, you muſt leave on the length of the Plate A B in this Figure, Plate enough to lap over for the *Joints*, I mean, to *Turn*, or *Double* about a round Pin, ſo big as you intend the Pin of your *Hinge* ſhall be, and alſo Plate enough to *Weld* upon the inſide of the *Hinge* below the *Pin-hole* of the *Joint*, that the *Joint* may be ſtrong.

The ſize, or diameter of the *Pin-hole*, ought to be about twice the thickneſs of the Plate you make the *Hinge* of, therefore lay a wyre of ſuch a diameter towards the end B, in this figure on the *Tial piece*, a-thwart the Plate as CD, and *Double* the end of the Plate B, over the wyre to lap over it, and reach as far as it can upon the end A; then *hammer* the Plate that is lap'd over the wyre cloſe to the wyre, to make the *Pin-hole* round; but if your Plate be thick, it will require the taking of



an

an *Heat*, to make it *hammer* the cloſer to the wyre, and conſequently make the *Pin-hole* the rounder: Your work may alſo ſometimes require to be Screwed into the *Vice*, with the doubled end upwards, and the bottom ſide of the wyre cloſe againſt the *Chaps* of the *Vice*, and then to *hammer* upon the very top of the *Pin-hole*, to round it at the end alſo. When you have made the *Pin-hole* round in the inſide, take the *Pin* CD out of the *Pin-hole*, and put the *Joint-end* of the *Hinge* into the Fire to make a *Welding-heat*; which when it hath, ſnatch it quickly out of the Fire, and *hammer*, or *weld*, the end B upon the *Tail-piece* A till they be incorporate together. But you muſt have a care that you *hammer* not upon the Plate of the *Pin-hole*, leſt you ſtop it up, or batter it; when it is well Welded, you muſt again put in the *Pin* CD, and if it will not well go into the *Pin-hole* (becauſe you may perhaps have *hammer'd* either upon it, or too near it, and ſo have ſomewhat cloſed it (you muſt force it in with your *hammer*; and if it require, take a *Blood-heat*, or a *Flame-heat*, of the *Joint* end) and then force the *Pin* into the *Pin-hole*, till you find the *Pin-hole* is again round within, and that the *Pin*, or Wyre, turn evenly about within it.

Afterwards with a *Punch* of hardned Steel (as you were taught *Numb.* I. *fol.* 11. 12.) *Punch* the *Nail-holes* in the Plate; or if your Plate be very thin, you may *punch* them with a *c* cold *Punch*. After all, *ſmooth* it as well as you can with your *Hand-hammer*; take a *Blood-red Heat*, if your Work require it, if not, *ſmooth* it cold; ſo ſhall the *Tail-piece* be fit for the *File*. *Double*, and *Weld* the *Croſs-piece*, as you did the *Tail-piece*.

Having *forg'd* your *Hinge* fit for the *File*, you muſt proceed to make the *Joint*, by cutting a notch in the middle of the *Pin-hole* between DD in Plate 2. on the *Croſs*, as at E, and you muſt cut down the ends of the *Pin-hole* on the *Tail-piece*, as at DD, till the *Joint* at C fit exactly into the notch in the *Croſs*, and that when the *Pin* is put into the

the *Pin-hole* DD on the *Croſs*, the *Pin-hole* in the *Tail-piece* may alſo receive the *Pin*; then by holding the *Tail-piece* in one hand, and the *Croſs* in the other, double the *Tail* and *Croſs* towards one another, to try if they move evenly and ſmoothly without ſhaking on the *Pin*; which if they do, the *Joint* is made; if they do not, you muſt examine where the Fault is, and taking the *Pin* out, mend the fault in the *Joint*.

Then *File* down all the irregularities the *Cold-Chiſſel* made on the edges of your Work, and (if the curioſity of work require it) *file* alſo the outer flat of your work. But *Smiths* that make quantities of *Hinges*, do *brighten* them, (as they call it) yet they ſeldom *file* them, but *Grinde* them on a Grind-ſtone till they become *bright*, &c.

Having finiſhed the *Joint*, put the *Pin* in again; but take care it be a little longer than the depth of the *Joint*, becauſe you muſt batter the ends of the *Pin* over the outer edges of the *Pin-hole*, that the *Pin* may not drop out when either edge of the *Croſs* is turned upwards.

The chiefeſt curioſity in the making theſe, and, indeed, all other *Hinges* is, 1. That the *Pin-hole* be exactly round, and not too wide for the *Pin*. 2. That the *Joints* are let exactly into one another, that they have no play between them, leſt they ſhake upwards or downwards, nor yet are forced too hard into one another, leſt when they are nailed on the door, the *Joint* be in danger of breaking. 3. That the *Croſs*, and the *Tail* lie on the under-ſide exactly flat, for ſhould they wrap out of flat when they are nailed on, the Nails would draw the *Joint* a-wry, and not only make it move hard, and unevenly, but by oft Opening and Shutting break the *Joint*. 4. If your Work be intended to be curious, the true *Square-filing* the upper-ſide, as you were taught *Numb.* I. *fol.* 14, 15, 16. is a great Ornament.

a Smiths call all *Chiſſels* they uſe upon cold Iron, *Cold-Chiſſels*.

b The *Stake* is a ſmall *Anvil*, which either ſtands upon a broad Iron foot, or Baſis, on the *Work-Bench*, to remove as occaſion offers; or elſe it hath a ſtrong Iron *Spike* at the bottom, which Iron *Spike* is let into ſome certain place of the *Work-Bench* not to be removed. Its office is to ſet ſmall cold Work ſtraight upon, or to Cut or Punch upon with the *Cold-Chiſſel*, or *Cold-Punch*.

c *Smiths* call all *Punches* they uſe upon cold Iron, *Cold-Punches*.

If the *Hinge* you are to make be large, and Plate-Iron is not ſtrong enough for it, you muſt *Forge* it out of flat Bar-Iron, as you were taught *Numb.* I. *Fol.* 8. to 13.

The manner of working *Duſtails*, *Fig.* 5. and *Side-hinges*, *Fig.* 6. *&c.* is (the ſhape conſidered) in all reſpects the ſame I have here ſhewed you in *Croſs-Garnets*; but in theſe (or others) you may (if your work require curioſity) inſtead of *Doubling* for the *Joint*, *Forge* the *Round* for the *Joint* of full Iron, and afterwards *Drill* a hole through it, for the *Pin-hole*; and by curious *Filing*, work them ſo true into one another, that both ſides of the *Hinge* ſhall ſeem but one piece; as I ſhall ſhew more at large, when I come to the making Compaſſes, and other Joints for Mathematical Inſtruments.

Of Locks *and* Keys.

AS there are *Locks* for ſeveral purpoſes, as *Street-door Locks*, called *Stock Locks*, *Chamber-door Locks*, called *Spring-Locks*, *Cupboard-Locks*, *Cheſt-Locks*, *Trunk-Locks*, *Pad-Locks*, *&c.* So are there ſeveral Inventions in *Locks*, I mean, in the making and contriving their *Wards*, or *Guards*. But the contrivances being almoſt innumerable, according to the various fancies of Men, ſhall be referred to another time to diſcourſe; and I ſhall now ſhew you the working of a *Spring-Lock*, which when you know how

to do, your Fancy may play with Inventions, as you beſt like.

In *Fig.* 2. A A A A the *Main plate*, B C the *Key-hole*, E D E the *Top-hook*, E E *Croſs-wards*, F the *Bolt*, G the *Bolt-Toe*, or *Bolt-Nab*, H the *Draw-back Spring*, I the *Tumbler*, K the *Pin* of the *Tumbler*, L L the *Staples*.

In *Fig.* 3. A A A A the *Cover-Plate*, B the *Pin*, D C D the *Main-ward*, D D *Croſs-wards*, E the *Step-ward*, or *Dap-ward*.

In *Fig.* 4. A the *Pin-hole*, B the *Step*, or *Dap-ward*, C the *Hook-ward*, D the *Middle*, or *Main Croſs-ward*, E E the *Croſs-ward*, F the *Main-ward*, G G *Croſs-ward*, H the *Shank*, I the *Pot*, or *Bead*, K the *Bow-ward*, L the *Bow*, B C D E E F G G the *Bit*.

Firſt, Cut out of an Iron Plate with a *Cold-Chiſſel*, the ſize and ſhape of the *Main-Plate*, as you were taught to cut the *Croſs* and *Tail-piece* of the *Croſs-Garnet*; then conſider what depth you intend the *Bit* of the *Key* ſhall have, and ſet that depth off on the *Main-Plate*, by leaving about half an Inch of Plate between the bottom of the *Key-hole*, and the lower edge of the *Main-Plate*, as at C (or more or leſs, according to the ſize of the *Lock*.) Then meaſure with a pair of *Compaſſes* between the bottom of the *Bit*, and the *Centre* of your *Key* (or your intended *Key*) and ſet that diſtance off from C to B, near the middle between the two ends of the *Main-Plate*, and with the [a] *Prick-punch* make there a mark to ſet one *foot* of your *Compaſſes* in, then opening your *Compaſſes* to the middle of the *Bit* of your intended *Key*, as to D, deſcribe the Arch E D E for the true place the *Top-hoop* muſt ſtand on.

Then cut out another piece of Plate as A A A A in *Fig.* 3. for a *Cover-plate*, with two pieces one on each ſide, long enough to make *Studs* of to turn downwards, and then outward again as F F, G G, that the *Cover-plate* may ſtand off the *Main-Plate*, the breadth of the *Bit* of the *Key*; and at the two end of theſe *Studs* Punch holes, as G G,

to

to *Rivet* the *Cover-Plate* into the *Main-Plate*. In the middle of this Plate make the *Centre*, as at B, then open your *Compaſſes* to three quarters the length of the *Bit*, and half the Diameter of the *Shank* of the *Key*, and placing one *foot* in the Point B, deſcribe with the other *foot* the Arch D C D for the true place of the *Main-ward*, then ſet your *Compaſſes* to a little more than half the Diameter of the *Shank*, and place one *foot* (as before) in the *Centre* B, and with the other *foot* deſcribe the ſmall Arch E, for the true place the *Step-ward*, or (as ſome call it) the *Dap-ward* muſt ſtand: So have you the true places of the *Wards*, for an ordinary *Spring-Lock*; you may (if the depth of your *Bit* will bear it) put more *Wards* in your Plates. But you muſt note, that the more *Wards* you put in, the weaker you make your *Key*; becauſe that to every *Ward* on the Plates, you muſt make a ſlit, or *Ward* in the *Bit* of the *Key*; and the more *Wards* you make, the weaker the Iron of the *Bit* will be; and then if the *Bolt* ſhoot not eaſily backwards, or forwards, the *Bit* may be in danger of breaking.

Having marked on your Plates the places of all your *Wards*, you muſt take thin Plate, and with *Hammering* and *Filing* make them both *b Hammer-hard*, and of equal thickneſs all the way. Then *file* one edge very ſtraight, by laying a *ſtraight Ruler* juſt within the edge of it, and drawing, or racing with a point of hardned Steel, a bright line by the ſide of the *Ruler*; *File* away the edge of the Plate to that line, then draw (as before) another ſtraight line parallel to the firſt ſtraight line, or which is all one, parallel to the filed Edge, juſt of the breadth you intend the *Wards* ſhall be, and File as before, only, you muſt leave two, or ſometimes three *Studs* upon this Plate, one near each end, and the other in the middle, to *Rivet* into the *Main-plate*, to keep the *Ward* fixt in its place. Therefore you muſt take care when you elect this thin piece of Plate, that it be broad enough for the *Ward*, and theſe

Studs too. Then laying the Plate a-thwart the *Pike* of the *Bickern*, hold your hand even with the *face* of the *Bickern*, and *hammer* this Plate down ſomewhat by the ſide of the *Pike*, and by degrees you may (with care taken) bring it unto a circular form, juſt of the ſize of that Circle you deſcribed on the *Main-Plate*; which when you have done, you muſt apply this *Ward* to the Circle you deſcribed on the *Main-Plate*, ſetting it in the poſition you intend it ſhall be fixed, and marking with a ſteel Point where the *Studs* ſtand upon that Circle, in thoſe marks *punch* holes to *Rivet* the *Studs* to. Work ſo by all the other *Wards*.

If you have a *Pin* to the *Lock*, *Punch* a hole through the *Centre* on the *Cover-Plate*, ſomewhat ſmaller than the Wyre you are to make your *Pin* of, becauſe you may then *file* one end of the *Pin* away to a *Shank*, which muſt fit the ſmaller hole on the Plate, and the whole thickneſs of the *Pin* will be a *Sholder*, which will keep the *Pin* ſteddy in the *Centre-hole* of the Plate, when the *Pin* is *Rivetted* into the Plate. But becauſe there is ſome Skill to be uſed in *Rivetting*, I ſhall, before I proceed any farther, teach you

The manner of Rivetting.

Rivetting is to batter the Edges of a *Shank* over a Plate, or other Iron, the *Shank* is let into, ſo as the Plate, or other Iron, may be clinched cloſe, and fixed between the battering at the end of the Shank and the Sholder. So that

When you *Rivet* a *Pin* into a hole, your *Pin* muſt have a *Sholder* to it thicker than the hole is wide, that the *Sholder* ſlip not through the hole, as well as the *Shank*; but the *Shank* of the *Pin* muſt be exactly of the ſize of the hole the Shank muſt be *Rivetted* into, and ſomewhat longer than the Plate is thick; *file* the end of the Shank flat, ſo

ſhall

ſhall the Edges of the end, the eaſilier batter over the Plate; then put your Shank into the hole wherein it is to be *Rivetted*, but be ſure you force the *Shank* cloſe up to the *Sholder*; then turn the top of this *Sholder* downwards (Plate and all) upon your *Stake*, but lay it ſo, as that the Sholder lie ſolid, and the Shank, at the ſame time, ſtand directly upright, and with your left hand, keep your work bearing hard upon the flat, or *face* of the *Stake*. Then holding your *hammer* in your right hand, hold the edge of the *face* of it dripping a-ſlope from the right hand outwards, and lay pretty light blows upon the edge of the end of the Shank, turning with your left hand your work round to the *face* of the *Hammer*, till you have battered the edges of the *Shank* quite round about; but this is ſeldom done, with once turning your work about; therefore you may thus work it round again and again, till you find it is pretty well *Rivetted*; then lay heavier blows upon it, ſometimes with the *face*, ſometimes with the *Pen* of the *hammer*, till the end of the Shank is battered effectually over the Plate.

One main conſideration in *Rivetting* is, that the *Pin* you *rivet* in, ſtand upright to the Plate, or other Iron you *rivet* it upon; for if it do not ſtand upright, you will be forced to ſet it upright after it is *rivetted*, either in the *Vice*, or with your *Plyers*, or with your *Hammer*, and that may, if your Plate be thin, bow it, or if it be thick, break the Sank, or elſe the Sholder of your *Rivet*, and ſo you loſe your labour, and ſometimes ſpoil your Work.

Another conſideration is, that when you *rivet* a *Pin* to any Plate, and you fear it may afterwards twiſt about by ſome force that may be offered it, you muſt, to provide againſt this danger, *file* the *Shank* you intend to *Rivet*, either Square, or Triangular, and make the hole in the Plate you *rivet* it into, of the ſame ſize and form, and then *rivet* in the *Shank*, as before. There are two ways to make your Hole, Square or Triangular, one is by *filing*

it

it into theſe forms, when it is firſt Punched round; the other by making a *Punch* of Steel, of the ſize and ſhape of the *Shank* you are to *rivet*, and *punching* that *punch* into the Plate, make the ſame form.

Now to return where I left off. The *Pins* and *Shanks* of theſe *Wards* muſt be made of a long ſquare form, becauſe, (the Plates of the *Wards* being thin) ſhould you make them no broader than the Plate is thick, the *Studs*, or *Shanks* would be too weak to hold the *Wards*, therefore you muſt make the *Rivetting-ſhank* three or four times, or ſometimes more, as broad as the Plate is thick, and then *rivet* them in, as you were taught juſt now.

Then place the *Cover-plate* upon the *Main-plate*, ſo as the *Centre* of the *Cover-plate*, may ſtand directly over and againſt the *Centre* of the *Main-plate*, and make marks through the hole G G, of the *Studs* of the *Cover-plate* upon the *Main-plate*, and on thoſe marks Punch holes, and fit two *Pins* into them, to faſten the *Cover-plate* on to the *Main-plate*, but you muſt not yet *rivet* them down, till the *Key-hole* be made, becauſe this *Cover-plate* would then ſtop the progreſs of the *File* through the *Main-plate*, when you *file* the *Key-hole*. When you have placed the *Cover-plate* upon the *Main-plate*, and fitted it on with *Pins*, ſo, as you may take it off, and put it on again, as your Work may require, you muſt *Punch* the *Key-hole*, or rather *drill* two holes cloſe by one another, if the *Key-hole* falls near the *Wards*, becauſe *Punching* may be apt to ſet the *Wards* out of form, and with ſmall *Files*, file the two holes into one another, to make the hole big enough to come at it with bigger *Files*, and then file your *Key-hole* to your intended ſize and ſhape.

The *Key-hole* being finiſhed, *forge* your *Key*, as you were taught, *Numb.* I. *fol.* 8. and if your *Key* is to have a *Pin-hole*, *drill* the hole in the middle of the end of the *ſhank*, then *file* the *Wards*, or Slits in the *Bit* with thin *Files*; yet ſometimes Smiths *Punch*, or *Cut* them with a *Cold-Chiſſel*,

ſel, at the ſame diſtances from the middle of the *Pin-hole* in the end of the Shank (which is the ſame *Centre* which was made before, in the *Main-plate* on the *Cover-plate*) which you placed the *Wards* at, from the *Centre* of the *Main* and *Cover-plate*. But before you *file* theſe *Wards* too deep into the *Bit* of the *Key*, make trials, by putting the *Bit* into the *Key-hole*, whether the *Wards* in the *Bit*, will agree with the *Wards* on the Plates, which if they do, you may boldly cut them to the depth of the *Wards* on the Plate; if not, you muſt alter your courſe till they do; but you muſt take great care in cutting the *Wards* down ſtraight, and ſquare to the ſides of the *Bit*; for if they be not Cut down ſtraight, the *Wards* on the Plates, will not fall in with the *Wards* in the *Bit* of the *Key*; and if they be not ſquare to the ſides of the *Bit*, the *Bit* will not only be weaker than it need be, but it will ſhew unhanſomely, and like a Botch to the Eye.

The *Croſs* and *Hookwards* is made, or, at leaſt, entred at the *Forge*, when the Iron hath a *Blood*, or almoſt a *Flame Heat*, yet ſometimes Smiths do it on cold Iron, with a thin *Chiſſel*, as you was taught *Numb.* I. *fol.* 11, 12. But you muſt take care that your *Chiſſel* be neither too thick, or too broad, for this Punching of *Wards* is only to give the thin *Files* entrance to the work; which entrance when you have, you may eaſily *file* your *Croſs*, or *Hook-wards*, wider or deeper, as your Work may require; but if your *Chiſſel* be too broad, or too thick, it will make the *Wards* in the *Bit* too long, or too wide, and then (as I ſaid before,) the *Bit* of your *Key* will prove weaker than it needs to be.

Having made the *Wards* on the Plate, and in the *Bit* of the *Key*, you muſt *Forge* the *Bolt* of a conſiderable ſubſtance, thick and ſquare at the end that ſhoots into the *Staple* in the frame of the Door, that it may be ſtrong enough to guard the whole Door; but the reſt of the

Bolt

Bolt that lies between the two *Staples* on the *Main-plate*, may be made very thin inwards, that is, the ſide that lies towards the *Main-plate*, which becauſe it cannot be ſeen when the *Bolt* is fixed upon the Plate, I have made a Figure of it, and turned the inſide to view, as in *Fig.* 4. where you may ſee, that the end A, hath a conſiderable ſubſtance of Iron to guard the whole Door, as aforeſaid, and B is a ſquare *Stud*, which doth as well keep the outſide flat of the *Bolt* on the Range, as ſerve for a *Stud* for the *Spring* H in *Fig.* 2. to preſs hard againſt, and ſhoot the *Bolt* forwards: This *Bolt* muſt be wrought ſtraight on all its ſides, except the Topſide, which muſt be wrought ſtraight only as far as the *Sholder* G, called the *Toe*, or *Nab* of the *Bolt*, which riſes, as you ſee in the Figure, conſiderably high, above the ſtraight on the Top of the *Bolt*: The office of this *Nab*, is to receive the bottom of the *Bit* of the *Key*, when in turning it about, it ſhoots the *Bolt* backwards, or forwards.

Having *forged* and *filed* the *Bolt*, you muſt fit the hollow ſide of it towards the *Main-plate*, at that diſtance from the *Key-hole*, that when the *Key* is put into the *Key-hole*, and turned towards the *Bolt*, the bottom of the *Bit* may fall almoſt to the bottom of the *Nab*, and ſhoot the *Bolt* back ſo much, as it needs enter the *Staple* in the *Door-frame*. And having found this true place for the *Bolt*, you muſt with ſquare *Staples*, juſt fit to contain the *Bolt* with an eaſie play, faſten theſe *Staples*, by *Rivetting* them with the *Bolt* within them, one near the *Bolt* end, the other near the *Nab* end, as at LL to the *Main-plate*.

Then *Punch* a pretty wide hole in the *Main-plate*, as at K, to receive a ſtrong *Pin*, and *file* a *ſholder* to the *Shank* of the *Pin* that goes into the Plate. This *Pin* is called the *Pin of the Tumbler*; the *Tumbler* is marked I, which is a long piece of Iron, with a round hole at the top to fit the *Pin* of the *Tumbler* into, that it may move upon it, as on a *Joint*, and it hath an *Hook* returning at the lower

er end of it, to fall into the breech of the *Bolt*, and by the *Spring* H forces the *Bolt* forwards, when it is ſhot back with the *Key*. This Spring is made of Steel, and afterwards temper'd (as I ſhall ſhew you in proper place.) It is fixed at the bottom of the *Main-plate*, by two ſmall Shanks proceeding from that edge of the *Spring* that lies againſt the *Main-plate*, as at O O: Theſe Shanks are to be *Rivetted* (as you were taught even now) on the other ſide of the *Main-plate*.

All things being thus fitted, *punch* an hole on each corner of the *Main-plate* for *Nails* to enter, that muſt nail the *Lock* to the *Door*. Or if you intend to *Screw* your *Lock* on the *Door*, you muſt make wide holes, big enough to receive the Shank of the *Screw*. Laſt of all, *rivet* down your *Cover-plate* to the *Main-plate*, and *file* your *Key*, and *poliſh* it too, if you will; ſo ſhall the *Lock* and *Key* be finiſhed.

a A *Prick-punch*, is a piece of temper'd Steel, with a round point at one end, to prick a round mark in cold Iron.

b Hammer-hard, is when you harden Iron, or Steel, with much hammering on it.

The making of Screws *and* Nuts.

THE Shank of the *Screw* for Doors, and many other purpoſes, muſt be *Forged* ſquare near the *Head*, becauſe it muſt be let into a ſquare hole, that it may not twiſt about when the *Nut* is turned about hard upon the *Screw-pin*. Therefore take a ſquare Bar, or Rod of Iron, as near the ſize of the *Head* of the *Screw-pin* as you can, and taking a *Flame-heat* of it, lay ſo much of this Bar as you intend for the length of the Shank, with one ſquare ſide flat, upon the hither ſide of the *Anvil*, and *hammer* it down to your intended thickneſs: But have a care you do not ſtrike your Iron on this ſide the edge of the *Anvil*, leſt you cut the Iron, as I told you *Numb.* I. *fol.* 11. Thus, at once, you will have two ſides of your Shank *forged*; the under-ſide made by the *Anvil*, and the up-

er-ſide beaten flat with the *Hammer*: The *Head* will be in the main Rodof Iron; then if your Iron grows cold, give it another *Heat*, and lay one of the unwrought ſides upon the hither-ſide of the *Anvil*, juſt to the *Head*, and *hammer* that down, as before, ſo ſhall the two other ſquare ſides be made; then *hammer* down the Corners of ſo much of this Shank, as you intend for the *Screw-pin*, and round it, as near as you can, with the *Hammer*; ſet then the *Chiſſel* to the thickneſs you intend the *Head* ſhall have, and ſtrike it about half through, then turn the ſides ſucceſſively, and cut each ſide alſo half through, till it be quite cut off. If the Sholder be not ſquare enough, hold it in your *ſquare-nos'd Tongs*, and take another *Heat*, and with ſpeed (leſt your Work cool) ſcrew the Shank into the *Vice*, ſo as the Sholder may fall flat upon the *Chaps* of the *Vice*; then *hammer* upon the *Head*, and ſquare the Sholder on two ſides, do the like for ſquaring the other two ſides. This was, in part, taught you before, in *Numb.* I. *fol.* 11. but becauſe the cutting this Iron Rod, or Bar, juſt above the Sholder makes the *Head*, and for that I did not mention it there, I thought fit (ſince the purpoſe required it) to do it here: The *Forging* of the *Nuts* are taught before, *Numb* I. *Fol.* 11, 12.

Having *forged* and *filed* your *Shank* ſquare, and the *Head* either ſquare or round, as you intend it ſhall be, *file* alſo the *Screw-pin*, from the riſings and dents left at the *Forge*; and *file* it a little tapering towards the end, that it may enter the *Screw-plate*; the Rule how much it muſt be Tapering is this, conſider how deep the Inner *Grooves* of the *Screw-plate* lie in the outer *Threds*, and *file* the end of the *Screw-pin* ſo much ſmaller than the reſt of the *Screw-pin*, for the outer *Threds* of the *Screw-plate* muſt make the *Grooves* on the *Screw-pin*, and the *Grooves* in the *Screw-plate*, will make the *Threds* on the *Screw-pin*. Having fitted your ſelf with a *hole* in your *Screw-plate* (that is, ſuch a *hole* whoſe Diameter of the hollow *Grooves*, ſhall be equal

qual to the Diameter of the *Screw-pin*, but not ſuch an *hole*, whoſe Diameter of the outer *Threds*, ſhall be equal to the Diameter of the *Screw-pin*, for then the *Screw-plate* will indeed turn about the *Screw-pin*, but not cut any *Grooves*, or *Threds*, in it) *ſcrew* the Shank with the *Head* downwards in the *Vice*, ſo as that the *Screw-pin* may ſtand directly upright, and take the *handle* of the *Screw-plate* in your Right-hand, and lay that *hole* flat upon the *Screw-pin*, and preſs it pretty hard down over it, and turn the *Screw-plate* evenly about with its *handle* towards you, from the Right towards the Left-hand, ſo ſhall the outer *Threds* of the *Srew-plate* cut *Grooves* into the *Screw-pin*, and the ſubſtance of the Iron on the *Screw-pin*, will fill up the *Grooves* of the *Screw-plate*, and be a *Thred* upon the *Screw-pin*. But take this for Caution, that, as I told you, you muſt not make your *Screw-pin* too ſmall, becauſe the *Screw-plate* will not then cut it, ſo if you make it too big (if it do enter the *Screw-plate* where it is Taper) it will endanger the breaking it, or, if it do not break it, yet the *Screw-plate* will, after it gets a little below the Tapering, go no farther, but work and wear off the *Thred* again it made about the tapering.

To fit the *Pin* therefore to a true ſize, I, in my Practiſe, uſe to try into what *hole* of the *Screw-plate*, the *Tap* or place of the *Tap*, (if it be a tapering *Tap*,) I make the *Nut* with, will juſt ſlide through; (*Threds* and all;) (which generally in moſt *Screw-plates* is the *hole* next above that to be uſed) for then turning my *Pin* about in that *hole*, if the *Pin* be irregularly *filed*, or but a little too big on any part of it, the *Threds* of that *Hole* will cut ſmall marks upon the *Pin*, on the irregular places, or where it is too big; ſo that afterwards *filing* thoſe marks juſt off, I do, at once, *file* my *Pin* truly round, and ſmall enough to fit the *Hole* I make my *Screw-pin* with.

As the *Hole* of the *Screw-plate* muſt be fitted to the *Screw-pin*, ſo muſt the *Screw-tap* that makes the *Screw*

in the *Nut*, be fitted to the round *hole* of the *Nut*; but that *Tap* muſt be of the ſame ſize of your *Screw-pin* too, which you may try by the ſame *hole* of the *Screw-plate* you made the *Screw-pin* with. *Screw* the *Nut* in the *Vice* directly flat, that the *hole* may ſtand upright, and put the *Screw-tap* upright into the *hole*; then if your *Screw-tap* have an *handle*, turn it by the *handle* hard round in the *Hole*, ſo will the *Screw-tap* work it ſelf into the *Hole*, and make *Grooves* in it to fit the *Threds* of the *Screw-pin*. But if the *Screw-tap* have no *handle*, then it hath its upper end filed to a long ſquare, to fit into an hollow ſquare, made near the *handle* of the *Screw-plate*; put that long ſquare hole, over the long ſquare on the top of the *Tap*, and then by turning about the *Screw-plate*, you will alſo turn about the *Tap* in the *hole*, and make *Grooves* and *Threds* in the *Nut*.

But though ſmall *Screws* are made with *Screw-plates*, yet great *Screws*, ſuch as are for *Vices*, *Hot-Preſſes*, *Printing-Preſſes*, &c. are not made with *Screw-Plates*, but muſt be cut out of the main Iron, with heavy blows upon a *Cold-Chiſſel*. The manner of making them, is as follows.

The Rules and manner of Cutting Worms *upon great* Screws.

THE *Threds* of *Screws*, when they are bigger than can be made in *Screw-plates*, are called *Worms*. They conſiſt in length, breadth and depth; the length of a *Worm* begins at the one end of the *Spindle*, and ends at the other; the breadth of the *Worm*, is contained between any two *Grooves* on the *Spindle*, *viz.* The upper and under *Groove* of the *Worm*, in every part of the *Spindle*; the depth of the *Worm*, is cut into the Diameter of the *Spindle*, *viz.* The depth, between the outſide of the *Worm*, and the bottom of the *Groove*.

The

The depth ought to be about the one Seventh Part of the Diameter, on each ſide the *Spindle*.

You ought to make the *Groove* wider than the *Worm* is broad, becauſe the *Worm* being cut out of the ſame intire piece with the *Spindle*, will be as ſtrong as the *Worm* in the *Nut*, tho' the *Worm* on the *Spindle* be ſmaller; for you cannot come at the *Worm* in the *Nut*, to cut it with *Files*, as you may the *Spindle*, and therefore you muſt either *Turn* up a Rod of Iron, to twiſt round about the *Grooves* on the *Spindle*, and then take it off, and *Braze* it into the *Nut*, or elſe you muſt *Caſt* a *Nut* of *Braſs* upon the *Spindle*, which will neither way be ſo ſtrong as the *Worm* cut out of the whole Iron, by ſo much as *Braſs* is a weaker Mettal than Iron, and therefore it is that you ought to allow the *Worm* in the *Nut*, a greater breadth than the *Worm* on the *Spindle*, that the ſtrength of both may, as near as you can, be equallized; for both being put to equal force, ought to have equal ſtrength. The *Worm* may very well be the One Seventh Part ſmaller than the *Groove* is wide, as aforeſaid.

Having conſidered what breadth the *Worm* on the *Spindle* ſhall have, take a ſmall thin Plate of Braſs, or Iron, and *file* a ſquare notch at the end of it, juſt ſo wide, and ſo deep, as your *Worm* is to be broad and deep, and *file* the ſides of the Plate that this notch ſtands between, juſt to the width of the *Groove*. This Plate, muſt be a *Gage* to *file* your *Worm* and *Groove* to equal breadth by; then draw a ſtraight and upright line the whole length of the *Spindle*; divide from this line the Circumference of the whole *Spindle* into eight equal parts, and through thoſe Diviſions, draw ſeven Lines more parallel to the firſt Line; then open your *Compaſſes* juſt to the breadth of one *Worm*, and one *Groove*, and ſet off that diſtance ſo oft as you can, from the one end of the Spindle to the other, (but I ſhould firſt have told you, that the end of your Spindle muſt be truly ſquare

to

to the outſide) and with a *Prick-Punch*, make a mark to every ſetting off on that line: Do the like to all the other ſtraight upright Lines. Note, that you may chuſe one of theſe eight upright lines for the firſt, and make the next towards your left hand, the ſecond (but then the firſt muſt ſtand towards you) and the next that, the third, and ſo on. And the top mark of every one of theſe upright ſtraight Lines, ſhall be called the firſt Mark, the next under that the ſecond Mark, the third, the third Mark, and ſo downwards in Order and Number.

Having marked one of theſe eight Lines at the top of the *Spindle*, to begin the winding of the *Worm* at, with a Black-lead Pencil, draw a line from that Mark to the ſecond Mark, on the next upright line towards the left hand, from thence continue drawing on with your Pencil to the third Mark, on the third upright line, draw on ſtill to the fourth Mark, on the fourth upright line, and ſo onwards, till you have drawn over the eight ſtraight lines, which when you have done, you muſt ſtill continue on, drawing downwards to each lower Mark on each ſucceſſive upright line, till you have drawn your *Worm* from end to end: Then examine, as well as you can, by your Eye, whether the *Worm* you have carried on from Mark to Mark with the Black-lead Pencil, do not break into Angles, which if it do any where, you muſt mend it in that place: Then with the edge of an *half-round File*, file a ſmall line in that Black-lead line, and be ſure that the line you are *filing*, run exactly through all the Marks that the Black-lead Pencil ſhould have run through (if it did not, for want of good guidance of the hand.) This ſmall line is only for a guide to cut the *Groove* down by; for the making of a *Screw* is, indeed nothing elſe, but the cutting the *Groove* down, for then the *Worm* remains: But you muſt not *file* in this ſmall line, but leave it as a guide

to

to lie on the middle of the *Worm* (as I ſaid before): Therefore to cut down the *Groove*, take a *Cold-Chiſſel*, ſomewhat thinner than you intend the *Groove* ſhall be wide, *viz.* about the thickneſs of the breadth of the *Worm*, and, with heavy blows, cut out the *Groove* pretty near. The reaſon why you ſhould not offer to cut the *Grooves* to their full width at the firſt, is, becauſe your Hand may carry the *Cold-Chiſſel* ſomewhat awry, and ſhould your *Cold-Chiſſel* be as thick as the *Groove* is wide, you could not ſmooth the Irregularities out, without making the *Worm* narrower than you intended it: Then with a *Flat-file* open and ſmooth the *Groves*, *filing* in the middle between the two next fine lines cut by the *Half-round File*, till you have wrought the *Spindle* from end to end, ſo ſhall the *Worm* remain. But you muſt not expect, that though the *Groove* be cut, it is therefore finiſhed, for now you muſt begin to uſe the thin *Plate-Gage*, and try Firſt, whether the *Worm* have equal breadth all the way. Secondly, whether rhe *Groove* have equal breadth all the way. And Thirdly, whether the *Groove* have equal depth all the way; and where ever you find the *Worm* too broad, you muſt *file* it thinner, and where the *Groove* is not deep enough, *file* it deeper; therefore in cutting down the *Groove* you may obſerve, that if, at firſt, you *file* the *Worm* ne'er ſo little too narrow, or the *Groove* ne'er ſo little too deep, you ſhall have all the reſt of the *Worm*, or *Groove*, to *file* over again; becauſe the whole *Worm* muſt be wrought to the breadth of the ſmalleſt part of it, and the whole *Groove* to the depth of the deepeſt place all the way, eſpecially if the *Nut* be to be *Caſt* in *Braſs* upon the *Spindle*; becauſe the Mettal running cloſe to the *Spindle* will bind on that place, and not come off it; but if the *Nut* be not to be *Caſt* in *Braſs*, but only hath a *Worm* brazed into it, this niceneſs is not ſo abſolutely neceſſary, becauſe that *Worm* is firſt *Turned up*, and bowed into the *Grooves* of

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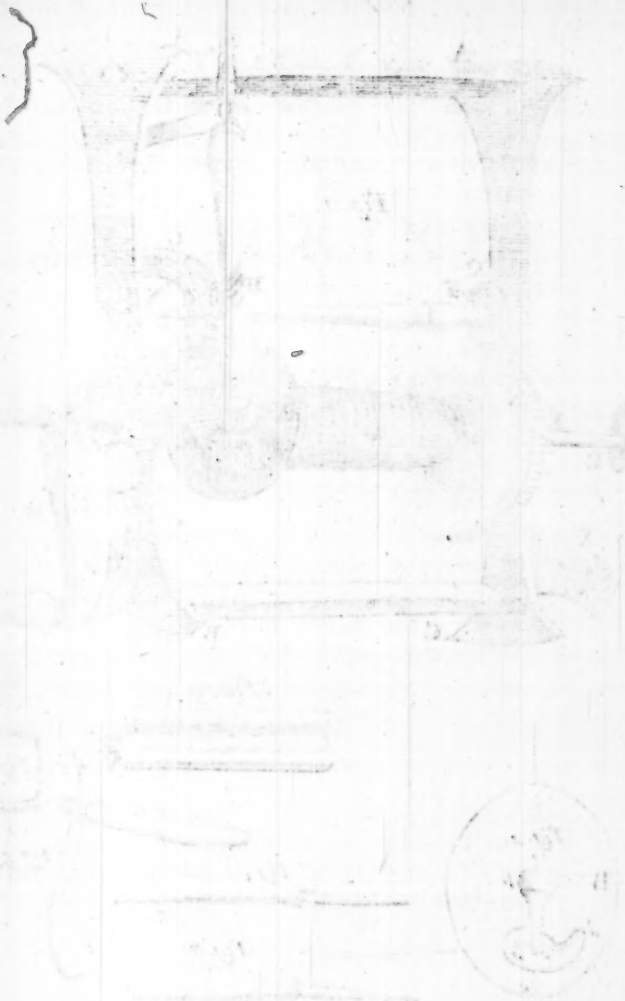
the *Spindle*, and you may try that before it is *Braz'd* into the *Nut*, and if it go not well about, you may mend, or botch it, either by *Hammering*, or *Filing*, or both.

The manner of *Caſting* the *Nut* upon the *Spindle*, I ſhall ſhew when I come to the *Caſting* of *Mettals*; and the manner of *Brazing* hath been Taught already. *Numb.* I. *fol.* 12, 13.

If your *Spindle* is to have three or four *Worms* winding about it, as *Coining-Preſſes*, and *Printing-Preſſes* have, that they may not wear out too faſt, you muſt divide the Circumference into three or four equal parts; and each of theſe equal parts, into two equal parts, and having ſtraight upright lines, drawn as before, begin a *Worm* at each of thoſe three, or four Diviſions, on the Circumference, and conſidering the breadth of your *Worm*, and width of your *Groove*, meaſure that width ſo oft as you can on all the upright lines, and making Marks on thoſe, at each Setting off, draw, as before, a line from the end of the *Spindle*, on the firſt upright line to the Mark below it, which is the ſecond Mark on the ſecond upright line, from thence to the third Mark, on the third upright line, and ſo on to the other end of the *Spindle*. Having drawn the firſt *Worm*, work the other *Worms* as this.

Thus much may, at preſent, ſuffice for *great Screws*; when I come to exerciſe upon *Printing*, I ſhall be more copious on Rules for *Printing-Preſs Spindles*.



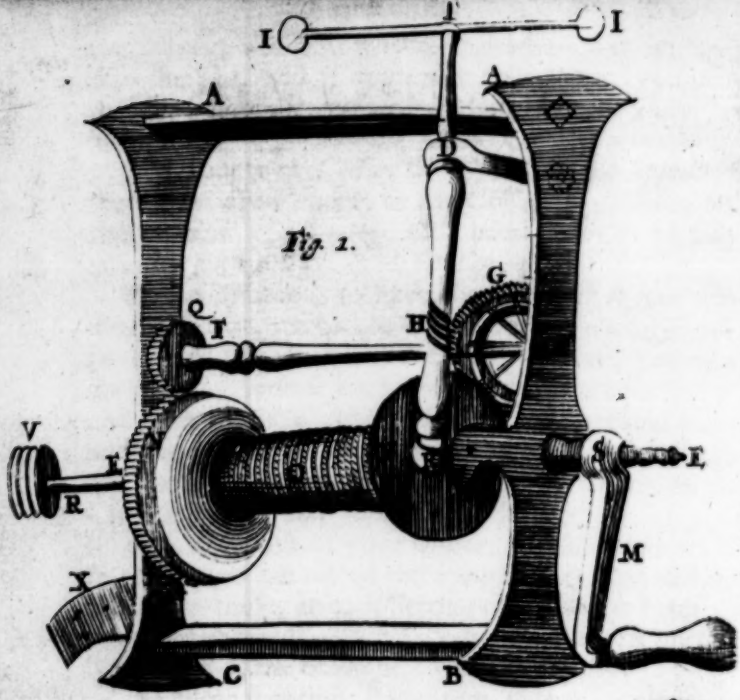


Fig. 1.

Fig. 4.

Fig. 3.

Fig. 2.

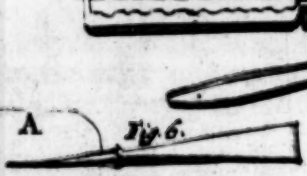


Fig. 6.

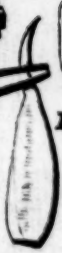


Fig. 5.

Fig. 7.

MECHANICK
EXERCISES:
OR, THE
DOCTRINE
OF
HANDY-WORKS.

By *Joseph Moxon*, late Member of the *Royal Society*, and *Hydographer* to King *Charles* II.

LONDON,

Printed and Sold by *J. Moxon*, 1693.

MECHANICK EXERCISES:

OR,

The Doctrine of *Handy-Works.*

Viz. *The making of Jacks, and Bullet-Molds, the twisting of Iron, and Case-hardning it, with the use of some Tools not treated of before: Also of the several Sorts of Steel, the manner of Softning, Hardning and Tempering them.*

Of Jacks.

FIg. 1. is called a *Worm-Jack.* A B the *Fore-side,* A C the *Back-side,* A A the *Top-piece,* B C the *Bottom-piece,* altogether the *Jack-Frame,* E E K the *Main-Spindle,* N O N the *Main Wheel* and *Barrel,* O the *Barrel,* D the *Wind-up-piece,* fastned into the *Barrel,* F F the *Worm-wheel Spindle,* G the *Worm-wheel,* Q the *Worm-Nut,* H the *Worm,* R the *Stud* of the *Worm-Spindle,* D the *Worm-Loop,* L the *Wind-up-piece,* M the *Winch,* or *Winder,* or *Handle,* the Iron part is the *Winder,* the Wood the *Handle,* S the *Eye of the Winder,* I I the *Fly,* T the *Socket* of the *Fly,* V the *Struck-Wheel,* X the *Stayes,* or *Back-fastnings.*

First you are to Forge the *Jack-frame,* and on the left side of the *Foreside,* a Shank for the *Stud* of the *Worm-spindle,* as you were taught, *Numb.* I. *fol.* 8, 9, 10, 11, 12. and then file it, as you were taught, *Numb.* I. *fol.* 14, 15, 16.

The *top* and *bottom Pieces* are let into square holes at the ends of the *Fore* and *Backsides.* But you must forge the *top* and *bottom Pieces* with two small Squares towards the ends of them, and two round ends for *Screw-pins,* beyond those squares. The small squares are to be fitted into square holes into the *Fore* and *Backsides,* and the round *Screw-pins* are to make *Screws* of, to which a square *Nut* is to be fitted

to draw the *top* and *bottom Pieces* close and tight up to the insides of the *Fore* and *Backsides*. The manner of filing of these square Ends you were, in part, taught, *Numb.* II. *fol.* 15, 16. and *Numb.* I. *fol.* 29. but another way is by trying your Work with an Instrument, called, by Workmen, a *Square*, as you see described in this Figure.

Of the Square, *and its Use.*

The sides ABC are called the *Outer-Square*; the sides DEF the *Inner-Square*. Its use is thus. If your work, as in this case, be an *Outer-square*, you must use the *Inner-square*, DEF to try it by; applying either the side ED, or DF (but suppose the side ED) to one of the sides of your work, chuse the flattest and truest wrought) if neither of the sides be flat, make one of them flat, as you were taught, *Numb.* I. *fol.* 15, 16. if then you find the side DF of your *Square* lie all the way even upon the adjoining side of your work, you may conclude those sides are Square; but if the adjoining side of your work comply not all the way with the adjoining side of the *Square*, you must file away your work where the *Square* rides upon it, till the whole side be wrought to comply with the adjoining side of the *Square*, that is, till both the sides of your work agree with both the sides of the *Squares*, when they are applied to one another. Having tried two sides square, make a third side of your work square, by applying one of the sides of the *Square* to one of those sides of your work, that are already made square, and, as before, try the third untried side, and make that Square; and by the same Rule make the the fourth side square.

If the work you are to file be an hollow square, you must apply the outer square A B C to it, and try how, when one side of the *Square*, is applied to one side of your work, the other side of your work agrees with the

the other ſide of the *Square*; which if it do, all is well: But if the *Square* and the Work comply not with one another, you muſt file your Work where it bears the *Square* off. But to return where I left.

Having made theſe two ends ſquare, you muſt fit the length of them to the thickneſs of the *Fore* and *Backſides* into which they are to enter, but ſo, as the ſquares be not full ſo long, as to come quite thro' the *Fore* and *Backſides*, leſt when the *Nuts* are ſcrewed on the *Screw-pins* that are at the ends of theſe Squares, they ſcrew full up to the Squares, and bear againſt the corners of them; which if they do, the *Nuts* will not draw the *Fore* and *Backſides* cloſe againſt the ſhoulder of the ſquares, on the *top* and *bottom Pieces*, and then the whole *Jack Frame* will not ſtand faſt and firm together.

But before you fit this *Frame* thus together, you muſt conſider the Diameter of the *Main Wheel*, that you may Punch round Holes in the *Fore* and *Backſides* to enter the *Main-ſpindle*. Therefore open your Compaſs to half the intended Diameter of the *main Wheel*, and half a quarter, or an whole quarter of an Inch more for play, between the Semi-Diameter of the *main Wheel*, and the upper flat of the *Bottom-piece*, and ſet that diſtance off from the upper flat of the *Bottom-Piece*, on the *Fore* and *Backſides*, and with a round Punch, ſomewhat ſmaller than the intended ſize of the *Main-ſpindle*, punch holes at that ſetting off. Your Punch muſt be ſmaller than the *Main-ſpindle*, becauſe the holes may perhaps not be ſo exactly round, or punched ſo truly upright, or perfectly ſmooth as they ought to be; and ſhould you make the holes ſo wide, at firſt, as they need to be, you could not mend them, without making them wider. Theſe holes muſt be punched at the *Fire*, or *Forge*, (as Smiths ſay, when they take an *Heat* of their work to punch it) becauſe the *Fore* and *Backſides* are *too ſtrong* (as Smiths ſay) that is, too thick to punch with the *Cold Punch*. The way of punching them you were taught *Numb.* I. *fol.* 11, 12. Beſides, a *Cold Punch* is

is commonly made flat at the bottom, and therefore does not prick an Hole, but cut an Hole (if the Iron be not too ſtrong) for that flat bottom, and the round upright ſide about it, meet in an Angle, or Edge, at the bottom, which edge, by the force of an Hammer, cuts the Iron (if it be not too ſtrong) when it is laid upon a *Bolſter*, as it is deſcribed, *Numb.* I. *fol.* 12. and ſhould you cut out ſo much Iron in the *Fore* and *Backſides*, as would entertain the *main Spindle* (it being thick) you would make the *Fore* and *Backſides* too wide; therefore, as I ſaid, the Holes muſt be prickt in the *Fore* and *Backſides* at the *Fire*, or *Forge*, which with a ſharp pointed *Punch* is ſooner done; nor does pricking diminiſh the ſubſtance or ſtrength of the Iron, but makes it ſwell out at the ſides, and retain both ſubſtance and ſtrength. The irregularity, or ſwellings out that this punching makes on the flats of the *Fore* and *Backſides*, you muſt hammer down again with almoſt a *Blood-red-heat*, I ſay, almoſt a *Blood-red-heat*; becauſe, ſhould you take too great an *Heat*, you may make the *Fore* and *Backſides* ſtretch, and ſo put the whole *Jack-Frame* out of order.

Having puncht the holes for the *main Spindle*, you muſt punch the holes in the *Fore* and *Backſides* for the *Worm-wheel Spindle*, as you puncht the holes for the *main Spindle*; but theſe muſt be ſmall holes, to entertain the ſmall Ends, or Pins of the *Worm-wheel Spindle*.

Theſe holes thus puncht, may perhaps not be exactly round, or fit your ſize, nor will they be ſmooth enough within; therefore, with a [a] *Square-bore*, you muſt [b] open them wider to your ſize, and that opening them in the inſide, will both round and ſmoothen them.

You muſt alſo punch a ſquare hole towards the top of the *Foreſide*, for the *Shank* of the *Worm-Loop*.

Then Forge and fit in your *Main-wheel Spindle*, and your *Worm-wheel Spindle*, which Spindles muſt both be exactly ſtraight between the centers of their two ends (unleſs you like to have Moldings for Ornaments on them) and forge a

ſquare

ſquare towards the ends of both the Spindles, to fit into a ſquare hole in the middle of the *Croſs* of their *Wheels*, and leave ſubſtance enough for a ſhoulder beyond the ſquare, to ſtop the ſquare hole in the *Croſs* of the *Wheels* from ſliding farther on the *Spindle*, and you muſt leave ſubſtance of Iron enough to forge the *Nut* of the *Worm-wheel* near the other end. But in this, and indeed, in all other forging, remember, (as I told you *Numb.* I. *fol.* 9.) that it behoves you to *Hammer*, or *Forge* your Work as true as you can, leſt it coſt you great pains at the *Vice*.

Then forge the *Worm-ſpindle*, which is all the way round and ſtraight, unleſs you will have Moldings for Ornaments (as aforeſaid) upon the *ſhank* of it: But you muſt be ſure to forge ſubſtance enough for the *Worm* to be cut out of it.

The *Main* and *Worm-wheels* are forged round and flat.

The manner of forging theſe Wheels (which in Smith's Language is, *Turning up the Wheels*) is, firſt, to draw out a ſquare Rod (as you were taught, *Numb.* I. *fol.* 9. among the ſeveral *Heats of Iron*) ſomewhat thicker than you intend your *Wheel* ſhall be; but it muſt be almoſt as thin on one ſide, as you intend the Inner edge of the *Wheel* ſhall be, and the oppoſite to it above twice that thickneſs, for the outer edge of the *Wheel*: (the reaſon you will find by and by.) Having drawn forth your ſquare Rod to a convenient length, *viz.* almoſt three times the Diameter of your intended Wheel, you muſt take almoſt a *Flame-heat*, and hammer all along the whole length upon the thick edge, ſo will you find the long Rod, by this hammering, turn by degrees rounder and rounder in upon the thin edge, which you hammer'd not upon, till it become a Circle, or pretty near a Circle. But you muſt make it ſomewhat more than a Circle, for the ends muſt lap over one another, that they may be *welded* upon one another.

Thus you may ſee the Reaſon for making the outer edge of the Rod thick, and the oppoſite edge thin; for your hammering upon the outer edge only, and not on

the inner, makes the outer edge a great deal thinner, and at the ſame time makes the Wheel broader.

The reaſon why I told you, you ſhould draw forth the Rod to almoſt three times the Diameter of the Wheel, and not to the Geometrical proportion, is, becauſe that in hammering upon it to make it round, the Rod will ſtretch ſo conſiderably, that it will be long enough to make a *Wheel* of your intended Diameter, and, moſt commonly, ſomewhat to ſpare. But to return.

Before you take a *welding Heat*, as by *Numb.* I. *fol.* 9. 10. you muſt flatten the two ends that are to be *welded* together, to a little more than half their thickneſs, that when they are lapt over one another, and *welded* together, they may be no thicker than the other part of the *Wheel*.

If the *Wheels* be not *turned up* ſo round, that with a little labour you may mend them at the *Vice*, you muſt with *Blood-red-heats* hammer them round upon the *Pike*, or *Bickern* of the *Anvil*, holding with your *Tongs* the inner edge of the *Wheel* upon it, and hammering upon the outer edge of the *Wheel*, till the *Wheel* be fit for the *Vice*: Their inſides muſt be divided into four equal parts, or four [c] *Dufftail* notches to be filed into them. The *Dufftail* notches are cut in the inner edge of the *Wheel* towards the outer edge of the *Wheel*, ſomewhat more than a quarter of an inch deep, and ſpreading ſomewhat wider towards the outer edge. Theſe notches are to receive the four ends of a *Croſs* forged ſomewhat thicker towards the ends than the thickneſs of the *wheel*, and muſt be filed outer *Dufftails*, to let exactly into the inner *Dufftail* notches made in the inſide of the *wheel*. They muſt be forged thicker than the *wheel*, becauſe they muſt batter over both the flat ſides of the *wheel*, to keep the *wheel* ſtrong and ſteddy upon the *Croſs*; and ſometimes (for more ſecurity) they are *brazed* into the *wheel* (yet that is but ſeldom;) the middle of this *Croſs* is made broad, that when the ſquare hole is made in the middle of it to receive the ſquare of the *Spindle*, it may have ſtrength enough to bear the violence offered it, as well in winding up the great

great weight, that keeps the *wheels* in motion, as in the checking and turning the *Jack-winder* back, to ſet the *Jack* a-going, when by the winding up, it may be ſubject to ſtand ſtill, or ſometimes, for want of weight, or elſe for want of oyling; or ſome other accident.

Theſe *wheels* thus forged and filed flat, muſt be divided, the *Main wheel* commonly into 64 equal parts, and the *Worm-wheel* into about 32 equal parts; but theſe numbers are not exactly obſerv'd by Smiths, for ſometimes they make them more, and ſometimes leſs, either according to the ſize of their *wheels*, or according as they intend their *wheels* ſhall go, ſwifter, or ſlower about (for the fewer the *Teeth* on a *wheel* are, the ſooner a *wheel* goes about, and the more *Teeth* on a *wheel*, the ſlower the *wheel* goes about) or ſometimes as they have opened their Compaſſes to divide them: For if, by luck, they at firſt open their Compaſſes to ſuch a width, as will juſt meaſure out on a Circle, (which they deſcribe on the center of the *wheel* for that purpoſe) their intended number, then the *wheel* ſhall have the intended number of *Teeth*; if not, let it ſomewhat fall ſhort, or exceed that number, they matter not, but make that number of *Teeth* on the *wheel*. And having thus divided the *wheel*, they, by the ſide of a ſtraight Ruler laid to the Center, and every diviſion markt on the *wheel*, draw or ſcratch a ſtraight line from the outer limb of the *wheel*, to the Circle, which Circle (I ſhould have told you before) is deſcribed at that diſtance from the outer Verge, they intend the *Teeth* ſhall be cut down to. This is indeed a rough way of working, but the Office of a *Jack* is well enough performed by this rough work; and the uſual prizes ſuch, as will ſcarce pay Workmen for better, as they ſay.

Theſe *wheels* thus divided, muſt be cut down into theſe diviſions with a d *Jack-file*, the *Main-wheel* ſtraight athwart the outer Verge, (which to ſpeak Mathematically, makes an Angle of 90 degrees with the flat ſides of the *wheel*,) and the *Worm-wheel* aſlope, making an Angle of about 115 de-

grees with its ſides, that is, an Angle of 25 degrees, with a line drawn ſtraight athwart the outer Edge of the *Wheel*, that the *teeth* of the *Worm-wheel* may gather themſelves into the *Grooves* of the *Worm* in the *Worm-ſpindle*; the *Worm* on the *Worm-ſpindle* running about 65 degrees aſlope from the Axis, or perpendicular of the *Worm-ſpindle*; the notches you make with the File muſt be ſo wide, as to contain about twice the thickneſs of each *tooth*: Therefore you may obſerve, that the number of *Teeth* cannot be aſſign'd, becauſe the Sizes of all *Jack-wheels* are not of equal Diameters, and the Sizes of the *Teeth* muſt be filed very ſquare and ſmooth, and the corners taken off, and rounded on both ſides towards the middle of the top, or end of the *Tooth*, which much helps the *Teeth* to gather in upon the *Teeth* of the *Nut*, and the *Worm* on the *Worm-ſpindle*.

The *Teeth* of the *wheels* being cut down, and the whole *wheel* finiſhed, they muſt be forced ſtiff and hard upon the ſquare of the *Spindle*, cloſe up to the Shoulder; which Square being made ſomewhat longer than the *Croſs* of the *wheel* is thick, muſt with a *Cold-Chiſſel* be cut on the top of that Square, to make the Iron that comes through the ſquare hole of the *wheel*, ſpread over the *Croſs* of the *wheel*, and then that ſpreading muſt be battered with the *Pen* of the Hammer; that it may ſtand up ſtiff againſt the ſhoulder of the Square, on the other ſide of the *wheel*; but in doing this, you muſt be very careful that the *Spindle* ſtand exactly perpendicular to the flat ſides of your *wheels*; for ſhould the *Spindle* lean never ſo little to one, or the other ſide of the *wheel*, the *wheel* when it is moving in the *Jack-frame* would not move perpendicular, but wabble towards the *Fore* or *Backſides* of the *Jack-frame*, and perhaps by this irregular motion, before a revolution of the *wheel* be performed, it would go off from the length of the *Teeth* of the *Nut*.

Then file the *Spindle-pins* (which are the ends of the *Spindle*, that go into the center-holes of the *Fore* and *Backſides* of the *Jack-frame*) exactly round and fit to their center-holes, and

and place them into their proper center-holes. Then try if the *wheels* are exactly round on their outer edges, and that in turning about, their flat ſides wabble not, but in a revolution keep parallel to the *Fore* and *Backſides*. The way *Smiths* uſe to try them by is, to turn them about by the *Spindle*, and holding a piece of Chalk ſteddy to the outer Limb of the *wheel*, not leting the point of the Chalk ſlip forwards or backwards, or towards the right or left hand, for then if the Chalk make a white ſtroke round the whole *wheel*, and that white ſtroke lie exactly parallel to the two outer edges of the *wheel*, the *Wheel* is not only round, but ſtands alſo true upon its *Spindle*, that is, perpendicular to the *Spindle*, and the *Spindle* perpendicular to the flat of it: But if the Chalk does not touch round the whole *wheel*, you muſt file down ſo much of the outer Verge of the *wheel*, where the Chalk does touch, as will bring down, or equalize the Diameter of the *wheel* in that place, to the Diameter of the *wheel* in the place where it does not touch; ſo may you conclude the *wheel* is round. If the mark of the Chalk lie not exactly in the middle between the two edges of the *wheel*, then it is not perpendicular to the *Spindle*, and you muſt with the Hammer ſet it right, that is, perpendicular, by forcing the *wheel* over from the ſide it leans too much to, or elſe by forcing the *Spindle*, which is all one; yet this is an help you ought not to rely upon to uſe, but in caſe of neceſſity, but rather be ſure your *Wheel* and *Spindle* ſtand perpendicular to one another, before you faſten the *Wheel* upon the ſquare of the *Spindle*, for by this help the ſquare on the *Spindle*, will be apt to looſen in the ſquare of the *Wheel*, and you will have your *wheel* to new faſten upon the ſquare of the *Spindle* again.

As you tried the *Wheels* with Chalk, ſo you muſt try the *Nut*, the *Worm*, and the *Spindles*.

The upper part of the *Worm-ſpindle*, muſt be filed truly round to fit into the *Worm-Loop*, that it ſhake not in it, and yet go very eaſily about, without the leaſt ſtopping. At the very

very upper end of this round on the *Worm-ſpindle*, you muſt file a ſquare to fit the ſquare hole of the *Fly* upon.

The *Shank* of the *Worm-Loop*, and the *Stud* of the *Worm Spindle*, muſt ſtand ſo far off the left ſide of the *Fore-ſide*, that the *Teeth* of the *Worm-wheel*, may fall full into the *Grooves* of the *Worm*; for ſo, both being cut with the ſame ſlope, the ſlope *Teeth* of the *Worm-wheel* will gather into the ſlope *Grooves* of the *Spindle*, and preſſing upon the *Worm*, drive about the *Worm-ſpindle* and the *Fly*.

The *Fly* is made ſometimes with two, ſometimes with four Arms from the center; and ſometimes the Arms are made longer, ſometimes ſhorter: The more Arms, and alſo the longer Arms, are to make the *Jack* go ſlower.

There is yet a ſmall matter more of Iron work about the *Jack*, which is the *Tumbler*; but it lies in the farther end of the *Barrel*, and cannot well be deſcribed without a particular figure, which therefore I have inſerted. As in *Fig.* 2. A the *Barrel*, B the *Main-ſpindle* coming through the *Barrel*, [a] the center of the *Tumbler* moving upon the *Center-pin*, which is faſtened into an Iron plate behind the *Barrel*. [b] The *Coller* upon the *Main-ſpindle*, from which proceeds a *Tongue*, which paſſes through a pretty wide hole at [c] in the *Tumbler*, as far as [e d] the *Catch of the Tumbler*. The *Tumbler* moves, as aforeſaid, upon the center hole [a], but receives the *Tongue* through it at [c], and paſſes as far as [e]. This *Tongue* ſerves as a *Check* to the *Tumbler*, that it cannot tumble above an Angle of 20 degrees, from the Iron plate it is faſtened to; and that the width of its center-hole, and the width of the hole the *Tongue* paſſes through, and the motion of the *Coller* about the *Main-ſpindle* allows it, but were the center hole a, and its *Center-pin* fit, and the hole c, and the *Tongue* that alſo paſſes through it alſo fit, and the *Coller* fixt, it could not move at all. But this play is enough for it, to do the purpoſe it is deſigned for. The *Tumbler* is ſo placed behind the *Barrel*, that while the *Jack-line* is winding up upon the *Barrel*, its round britch paſſes forwards by

by all the *Croſſes* of the *Main-wheel*, and the *Point* or *Catch*[d], as then claps it ſelf ſnug or cloſe to the Iron plate of the *Barrel*: But when the *Barrel* is turned on the contrary way, the weight of the *Catch* in half a revolution of the *Barrel* (let the *Tumbler* be poſited where it will) makes it open and fall from the Iron plate, and but againſt one or other of the *Croſſes* on the *Main-wheel*, and ſo thruſts the *Main-wheel* about with the *Barrel*.

The *Eye* of the *Winch*, or *Winder*, is forged as you were taught to forge the *Pin-hole* in the *Croſs-garnet*, *Numb.* II. *fol.* 18. But that was to be a ſmall round hole, and therefore you were directly to lay a ſmall round piece of Iron, or Wyre, where you intended the Pin-hole ſhould be, and lap the other end of your work over it; but this is to be a wide ſquare hole, therefore you muſt lay a ſquare piece of Iron of your ſize, where the *Eye* of the *Jack-Winch* ſhall be, and lap or double the other end over it, and *Weld* and Work as you were there directed. The reſt of the *Winch* is but common *Forging* and *Filing* work, which hath been ſufficiently taught already.

The Wood-work belonging to a *Jack*, is a *Barrel*, a *Spit-wheel*, and a *Handle of the Winch*; which being *Turners* work, I ſhall ſay nothing to, till I come to the Art of *Turning*. Only thoſe *wheels* that have more than one *Groove* in them, are called Two, Three, *&c. Struck-wheels*, in Workmens corrupting Language; but, I ſuppoſe, originally two *Stroak*, three *Stroak-Wheels*, *&c.* from the number of *Grooves* that are in them.

The Excellencies of a good *Jack* are, 1. That the *Jack-Frame* be forged and filed ſquare, and conveniently ſtrong, well ſet together, and will ſcrew cloſe and tight up. 2. That the *Wheels* be perpendicularly, and ſtrongly fixed on the ſquares of the *Spindles*. 3. That the *Teeth* be evenly cut, and well ſmoothed, and that the *Teeth* of the *Worm-wheel* fall evenly into the *Groove* of the *Worm*. 4. That the *Spindle Pins* ſhake not between the *Fore* and *Backſides*, nor are too big, or too little, for their Center-holes.

The

[a] The *Square-bore*, is a ſquare Steel Point, or Shank, well temper'd, fitted into a ſquare Socket in an Iron *Wimble*: It is deſcribed, *Fig.* 3. Its uſe is to open a Hole, and make it truly round, and ſmooth within; when you uſe it, you muſt ſet the Head againſt your Breaſt, and put the point of the *Square-bore* into the hole you punched, or would *open*, and turning the handle about, you with it turn about the Shank of the *Square-bare*, whoſe edges cut away the irregularities of the Iron made in the Punching. But you muſt thruſt, or lean hard with your Breaſt againſt the Head of the *Square-bore*, that it may cut the faſter: And you muſt be ſure to guide the *Square-bore* truly ſtraight forwards in the hole, leſt the hole be wrought aſloꝛe in the Iron.

[b] To *open an hole*, is in Smith's Language, to make the hole wider.

[c] A *Dufftail*, is a Figure made in the form of a Doves-tail, and is uſed by many other Handy-crafts, as well as by Smiths, but moſt eſpecially by Joyners, as I ſhall ſhew, when I come to *Joynery*.

[d] A *Jack-file*, is a broad File ſomewhat thin on both Edges, and ſtronger in the middle.

The manner of making Molds to Caſt Leaden Bullets in.

I inſert the making of *Bullet-Molds*, becauſe there is ſome ſort of Work in them different from what hath yet been taught. The Handles, and the Heads are forged as other Work, but the two concave Hemiſpheres, are firſt punched with a round-ended *Punch*, of the ſhape, and almoſt of the ſize you intend the *Bullet* ſhall be. They muſt be punch'd deep enough at the *Forge* with a *Blood-red-heat*; then are the Edges of the Chaps filed flat, firſt with a Common-file, the Common-way, but afterwards with an *Uſing-file*, as Workmen call it. The *Uſing-file*, is a long and broad File, exactly flat on both its cut ſides, having a ſquare Iron handle drawn out at one end, with an hole in it; but the handle is not to hold it by when you uſe it, but the hole

in

in it to go over a pin you hang it upon, when you do not uſe it. When you uſe it, you muſt lay it flat upon the Work-bench, with its handle from you, and you muſt take care that it lie ſolid and ſteddy, leſt when you work upon it, it ſlip from you; therefore you may ſtrike a Nail in at the hole in the handle, a little way into the Work-Bench, that you may draw it again, when you have done with the *Uſing-file*, and you may drive in a ſmall Tack on each ſide the *Uſing-file*, to keep it ſteddy, or you may tack down two ſmall thin boards on either ſide the *Uſing-file*, to keep it ſteddy, and rip them off again when you have done. Your *Uſing-file* lying thus ſtraight, and ſteddy before you, lay the Chaps of one half of the *Mold* flat upon the hither end of the *Uſing-file*, and holding your two Thumbs, and your two Fore-fingers upon the head of the *Mold*, thruſt your work hard down from you the whole length of the *Uſing-file*, then draw your work lightly back, and thruſt it again hard from you; reiterate theſe thruſts thus, till upon the Chaps of the *Mold*, you can ſee no irregularities, or the File-ſtroaks of the common File left, ſo may you be ſure that the Chaps of the *Mold* is truly flat. Do the like by the other half of the *Mold*.

Now you muſt try whether each of theſe concaves be an exact half-round; thus, you may deſcribe an Arch a little more than a Semi-Circle, juſt of the Diameter of your *Bullet*, upon the end of a thin piece of Braſs-latin, draw a ſtraight line through the center, and the Arch on both ſides it, for the limits of a Semi-circle; file very curiouſly all the Braſs away on the end, juſt to this Semi-circle, and juſt to the Diametral line on either ſide of the Semi-circle, ſo have you a convex Semi-circle: Put this convex Semi-circle into the concave *Molds*, if it fits them ſo as the convex reaches juſt the bottom of the *Molds*, when its ſhoulder touches juſt the chaps of the *Mold*, they are each a true concave Hemiſphere. But if the ſhoulder of the convex (that is, a Diametral Line prolong'd) rides upon the chaps of the Concave, and the bot-

tom of the Convex touch not the bottom of the Concave, the Concave is punched too deep, and muſt have its chaps rubb'd upon the *Uſing-file* again, till it comply with the convex. Then put into the two Concaves a round *Bullet*, that will juſt fill them both, and pinching the Heads of the *Mold* cloſe together in a *Vice*, with the *Bullet* in it, drill an hole through both the handles for the *Joint*. The reaſon why the *Bullet* is put into the *Mold* is, becauſe the Chaps of the two Halves ſhould lie exactly upon one another, whilſt the hole for the *Joint* is drilling. Then fit a Rivet-pin for this hole, and rivet them together, but not ſo hard, but that the *Mold* may open and ſhut pretty eaſy, and yet go true. Then take the *Bullet* out, and file in each half of the head, half a round hole directly againſt one another for the [a] *Geat*, which two half holes, when the *Mold* is ſhut, will make one round hole.

You may now try with Clay, or by caſting a leaden *Bullet* in it, whether it be exactly round or no; for making a true round hole in a thin piece of Braſs, juſt of the circumference of the chaps, you may try if the *caſt Bullet* will juſt paſs thro', and alſo fill that hole when the *Bullet* it turned every way; which if it do, you may conclude the *Mold* is true. This thin piece of Braſs, with a round hole in it, is called a *Sizer*.

But the inſide wants cleanſing, for hitherto it is only punched. Therefore you muſt provide a [b] *Bullet-bore*, with which you may bore the inſide of each half to clear it. Or if they be not quite deep enough punch'd, you may bore them deeper. You may bore them ſeverally, or together, by putting the *Bullet-bore* into the *Mold*, ſo as the *Shank* may come through the *Geat*.

In this Section you ſee, firſt the uſe of a *Uſing-file*, an Inſtrument of great uſe for flat Filing; for by it you may make two pieces of Iron of ſomewhat conſiderable breadth, ſo true, that by laying the two flat ſides upon each other, they ſhall draw up one another. It is much uſed by *Clock-*

makers,

makers, *Watch-makers*, *Letter-Mold-makers*, and indeed, all others that frame Square-Work on Iron, Steel, or Braſs. Secondly, the uſe of a *Bullet-bore*, which, tho' it be ſeldom uſed, yet it may ſerve, not only for *Bullet-Molds*, but for other purpoſes; and by altering its ſhape into an Oblong, a Cone, or a Cilinder, you may *Bore* theſe hollow Figures either for *Molds*, or ſome other accidental Uſes.

[a] A *Geat*, is the hole through which the Mettal runs into the *Mold*. The Word is uſed by moſt *Founders*.

[b] The *Bullet-bore*, is a *Shank* of Steel, having a ſteel *Globe*, or *Bullet* at one end, juſt of your intended *Bullet's* ſize. This Globular end muſt be hatched with a fine cut, by a *File-cutter*, and Hardned and Tempered. The end of the *Shank*, this Globular *Bore* is faſtned to, muſt be round and ſo ſmall, that when the *Bullet-bore* is in the *Mold*, the *Geat* will eaſily receive it. The other end of the *Shank* muſt be fitted into the ſquare Socket of the *Wimble*, and have a Shoulder to it to ſtop the Socket from ſliding too far upon the *Shank*. From this Shoulder, the reſt of the *Shank* muſt run tapering down, to the ſmall end the *Bullet-bore* is faſtned to. You muſt work with it, as you were taught to work with the *Square Bore*.

Of Twiſting of the Iron.

Square and flat Bars, ſometimes are, by Smiths, *twiſted* for Ornament. It is very eaſily done; for after the Bar is ſquare, or flat Forged (and if the curioſity of your work require it truly filed) you muſt take a *Flame-heat*, or if your work be ſmall, but a *Blood-red-heat*, and you may twiſt it about, as much, or as little as you pleaſe, either with the *Tongs*, *Vice*, or *Hand-Vice*, &c.

Of Caſe-Hardning.

Caſe-Hardning, is ſometimes uſed by *File-Cutters*, when they make courſe *Files* for Cheapneſs, and generally moſt *Raſps* have formerly been made of Iron, and *Caſe-hardned*, becauſe it makes the outſide of them hard. It is uſed alſo by *Gun-Smiths*, for hardning their Barrels; and it is uſed for *To-*

bacco-boxes, Cod-piece Buttons, Heads for walking Staves, &c. And in theſe Caſes, Workmen, to ſet a greater value on them in the Buyers eſteem, call them *Steel-barrels*, *Steel-tobacco-boxes*, *Steel-buttons*, *Steel-heads*, &c. But Iron thus hardned, takes a better Polliſh, and keeps the Polliſh much longer and better, than if the Iron were not *Caſe-hardned*. The manner of *Caſe-hardning* is thus, Take *Cow-Horn*, or *Hoof*, dry it throughly in an Oven, and then beat it to Powder, put about the ſame quantity of Bay-Salt to it, and mingle them together with ſtale Chamberley, or elſe with White-Wine-Vineger. Lay ſome of this mixture upon Loam, made, as you were taught *Numb.* I. *fol.* 13. And cover your Iron all over with it; then wrap the Loam about all, and lay it upon the Hearth of the Forge to dry and harden: When it is dry and hard, put it into the Fire, and blow up the Coals to it, till the whole Lump have juſt a *Blood-red-heat*, but no higher, leſt the quality of your mixture burn away, and leave the Iron as ſoft as at firſt. Then take it out, and quench it. Or, inſtead of Loam, you may wrap it up in Plate Iron, ſo as the mixture may touch every part of your Work, and blow the Coals to it, as aforeſaid.

Of ſeveral Sorts of Steel in common uſe among Smiths.

The difficulty of getting good Steel makes many Workmen (when, by good hap, they light on it) commend that Country-Steel for beſt, from whence that Steel came. Thus I have found ſome cry up *Flemiſh-Steel*, others *Swediſh-Steel*, others *Engliſh*, *Spaniſh*, *Venice*, &c. But according to my Obſervation, and the common conſent of the moſt ingenious Workmen, each Country produces almoſt indifferently good and bad; yet each Country doth not equally produce ſuch Steel, as is fit for every particular purpoſe, as I ſhall ſhew you by and by. But the ſeveral Sorts of Steel, that are in general uſe here in *England*, are the *Engliſh-Steel*, the *Flemiſh*, the *Swediſh*, the *Spaniſh*, and the *Venice-Steel*.

The

The *Engliſh-Steel* is made in ſeveral places in *England*, as in *Yorkſhire*, *Glouceſterſhire*, *Suſſex*, the *Wild of Kent*, &c. But the beſt is made about the *Forreſt of Dean*, it breaks Fiery, with ſomewhat a courſe Grain. But if it be well wrought, and proves ſound, it makes good Edge-Tools, Files and Punches. It will work well at the Forge, and take a good Heat.

The *Flemiſh-Steel* is made in *Germany*, in the Country of *Stiermark*, and in the *Land of Luyck*: From thence brought to *Colen*, and is therefore ſometimes called *Colen-Steel*; from *Colen* it is brought down the River *Rhine* to *Dort*, and other parts of *Holland* and *Flanders*, ſome in *Bars*, and ſome in *Gads*, and is therefore, by us, called *Flemiſh-Steel*, and ſometimes *Gad-Steel*. It is a tough ſort of Steel, and the only Steel uſed for Watch Springs. It is alſo good for Punches; File-cutters alſo uſe it to make their Chiſſels of, with which they cut their Files. It breaks with a fine Grain, works well at the Forge, and will take a *welding* Heat.

I cannot learn that any Steel comes from *Sweden*, but from *Dantzick* comes ſome which is called *Swediſh-Steel*: It is much of the ſame quality and fineneſs with *Flemiſh-Steel*.

The *Spaniſh-Steel* is made about *Biſcany*. It is a fine ſort of Steel, but ſome of it very difficult to work at the Forge, becauſe it will not take a good Heat; and it ſometimes proves very unſound, as not being well *curried*, that is, well wrought. It is too quick (as Workmen call it) that is, too brittle for Springs, or Punches, but makes good fine Edged Tools.

Venice-Steel is much like *Spaniſh-Steel*, but more fine, and works ſomewhat better at the Forge. It is uſed for Razors, Chirurgion's Inſtruments, Gravers, &c. Becauſe it will come to a fine and thin Edge. Razor-makers generally clap a ſmall Bar of *Venice-Steel* between two ſmall Bars of *Flemiſh-Steel*, and ſo work, or weld them together, to ſtrengthen the back of the Razor, and keep it from cracking.

There is another ſort of Steel of higher commendations, than any of the foregoing ſorts. It is called *Damaſcus-Steel*; 'tis very rare, that any comes into *England* unwrought

wrought, but the *Turkiſh*-Symeters are generally made of it. It is moſt difficult, of any Steel, to work at the Forge, for you ſhall ſcarce be able to ſtrike upon a Blood-heat, but it will *Red-Sear*; inſomuch that theſe Symeters are, by many Workmen, thought to be caſt Steel. But when it is wrought, it takes the fineſt, and keeps the ſtrongeſt Edge of any other Steel. Workmen ſet almoſt an ineſtimable value upon it, to make Punches, Cold Punches, &c. of. We cannot learn where it is made, and yet, as I am informed, the Honourable Mr. *Boyl* hath been very careful and induſtrious in that inquiry; giving it in particular charge to ſome Travellers to *Damaſcus*, to bring home an account of it: But when they came thither they heard of none made there, but were ſent about fifty Miles farther into the Country, and then they were told of about fifty Miles farther than that: So that no certain account could be gained, where it is made. *Kirman* towards the Ocean affords very fine Steel, of which they make Weapons highly prized; for a Symeter of that Steel, will cut through an *Helmet* with an eaſy blow. *Geog. Rect. fol.* 279.

The Rule to know good Steel by.

Break a little piece of the end of the Rod, and obſerve how it breaks; for good Steel breaks ſhort off, all gray, like froſt work Silver. But in the breaking of the bad, you will find ſome veins of Iron ſhining and doubling in the Steel.

Of Nealing of Steel.

Having choſe your Steel, and forged it to your intended ſhape, if you are either to file upon it, or engrave upon it, or to Punch upon it, you ought to Neal it firſt, becauſe it will make it ſofter, and conſequently work eaſier. The common way is to give it a *Blood-red-heat* in the Fire, then take it out, and let it cool of it ſelf.

There are ſome pretenders to know how to make Steel as ſoft as Lead; but ſo oft as my Curioſity has prompted me to try their pretended Proceſſes, ſo oft have they failed me; and not only me, but ſome others, careful Obſervers.

ſervers. But the Way they moſt boaſt of, is the often heating the Iron, or Steel in red-hot Lead, and letting it cool of it ſelf, with the Lead. I have many times tried this without any other ſucceſs, than that it does indeed make Iron or Steel as ſoft, as if it were well Neal'd the common way, but no ſofter: And could it be otherwiſe, the ſmall Iron Ladles, that Letter-Founders uſe to the caſting of Printing-Letters, would be very ſoft indeed; for their Iron Ladles are kept conſtantly Month after Month in mel-Mettal, whereof the main Body is Lead, and when they Caſt ſmall Letters, they keep their Mettal red hot; and I have known them many times left in the Mettal, and cool with it, as the Fire has gone out of it ſelf; but yet the Iron Ladles have been no ſofter, than if they had been well Neal'd the common way. But perhaps theſe Pretenders mean the Iron or Steel ſhall be as ſoft as Lead, when the Iron or Steel is red-hot: If ſo, we may thank 'um for nothing.

But that which makes Steel a very ſmall matter ſofter than the common way of Nealing is, by covering Steel with a courſe Powder of Cow-Horns, or Hooves, or Rams-Horns, and ſo incloſing it in a Loam; then put the whole lump into a wooden Fire to heat red-hot, and let it lie in the Fire till the Fire go out of it ſelf, and the Steel cool with the Fire.

Of Hardning and Tempering Steel.

Engliſh, *Flemiſh* and *Swediſh*-Steel, muſt have a pretty high heat given them, and then ſuddenly quench'd in water to make them very hard; but *Spaniſh* and *Venice*-Steel, will need but a Blood-red-heat, and then when they are quenched in Water, will be very hard. If your Steel be too hard, that is, too brittle, and it be an Edged, or Pointed Inſtrument you make, the edge, or point, will be very ſubject to break; or if it be a Spring, it will not bow, but with the leaſt bending it will ſnap aſſunder: Therefore you muſt *let it down*, (as Smiths ſay) that is, make it ſofter, by *tempering* it. The manner is thus, take a piece of Grin-

ſtone,

Stone, or Whetstone, and rub hard upon your work to take the black scurff off it. and brighten it; then let it heat in the Fire, and as it grows hotter, you will see the Colour change by degrees, coming first to a light Goldish colour, then to a darker Goldish colour, and at last to a Blew colour; elect which of these Colours your Work requires, and then quench it suddenly in Water. The *Light Goldish Colour* is for *Files*, *Cold-Chissels* and *Punches*, that Punch into Iron and Steel: The *Dark Goldish Colour* for Punches to use on Brass, and generally for most *Edge-Tools*: The *Blew-Colour* gives the Temper to *Springs* in general, and is also used to beautifie both Iron and Steel; but then Workmen sometimes grind *Indico* and *Sallad-Oyl* together, and rub that mixture upon it, with a woollen Rag, while it is heating, and let it cool of it self.

There is another sort of *Hardning*, called *Hammer-hardning*. It is most used on Iron, or Steel Plates, for *Dripping-Pans*, *Saws*, *Straight-Rulers*, &c. It is performed only with well Hammering of the Plates, which both smooths them, and beats the Mettal firmer into its own Body, and somewhat hardens it.

The manner of Forging Steel, either for *Edge-Tools*, *Punches*, *Springs*, &c. Is (the several shapes considered) the same with forging Iron: Only this General Rule observe, from an Old *English* Verse used among *Smiths*, when they Forge *Edge-Tools*,

He that will a good Edge win,
Must Forge thick, and Grind thin.

FINIS.